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Volume 11, Number 1, January 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
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Diagnostic Dental X Rays and the Patient–an Overview

Bureau of Radiological Health

In 1964, approximately one quarter of the civilian non-institutional population in the United States was exposed to dental x rays. The average estimated skin exposure was 1,144 mR per film. The absorbed doses were on the order of 25–30 mrad to organs in or near the direct beam with a genetically significant dose of <0.01 mrad per year. The status of exposure control programs and standards and compliance is discussed and activities for further reducing exposure are identified.

In order to evaluate the overall significance of the various sources of ionizing and non-ionizing radiation which may result in exposure to the U.S. population, it is necessary to place the contributions of each source into perspective. The purpose of this paper is to review the dental x-ray experience of the U.S. population, present exposure and dose estimates for this source of radiation and to summarize the current status of standards and compliance in the United States. Recommendations are made to further define unknown parameters and to reduce patient exposure from this source of x-radiation.

The annual exposure received by a population from diagnostic dental x rays is dependent not only on the parameters that affect the amount of radiation emitted from dental x-ray machines, but also on the frequency of dental x-ray examinations in a given population. Recent surveys have provided information on the number of people in various population groups who had diagnostic medical (*1–3*) and dental x-ray examinations (*4*). Such information is now available for the United States civilian population from a study (*5*) conducted by the U.S. Public Health Service in 1964. Estimates from the latter study indicate that 108 million (58 percent) of the 187 million civilian non-institutional persons in the population had one or more x-ray visits during 1964; about 46 million of these had dental x rays. Moreover, 12 percent of this group had more than one dental examination during that year.

Variations were found in the dental x-ray visits for different demographic groups of the population (*5*). The rate of dental x-ray visits is higher among females than among males in each age group; the highest rate among males was in the age group 30–44 years, while for females the rate was highest in the 15–29 year age group (table 1). Data in table 2 indicate that dental x-ray visits are positively correlated with family income and education level of the head of the household; the annual rate of dental visits among white persons is about three times the rate among the non-white populations; people who reside in rural areas have lower rates of visits for dental x-ray examinations than do

Table 1. Estimated annual rate of dental x-ray visits in the United States by age and sex, 1964[a]

Age	Dental x-ray visits per 100 persons		
	Both sexes	Male	Female
Under 15	20.6	18.5	22.8
15–29	37.6	30.4	44.1
30–44	36.0	33.6	38.2
45 and over	20.2	18.7	21.6
All ages	26.8	23.7	29.8

[a] PHS X-ray Exposure Study (*5*) page 78.

Table 2. Estimated annual rate of dental x-ray visits by selected population characteristics, United States, 1964[a]

Selected population characteristics	Dental x-ray visits per 100 persons
Education of household head:	
0–8th grade	10.2
9–12th grade	25.7
College	46.5
Family income:	
Under $2,000	11.3
$2,000–$3,999	15.0
$4,000–$6,999	23.2
$7,000 and over	30.9
Color:	
White	29.2
Non-white	8.8
Residence:	
Metropolitan	30.8
Non-metropolitan	
Non-farm	20.9
Farm	12.4
Region:	
Northeast	22.2
North Central	24.7
South	17.2
West	30.5

[a] PHS X-ray Exposure Study (*5*) page 79.

people who live in metropolitan areas; the West had the highest rate of visits and the South, the lowest.

Another indicator of the extent of radiation exposure to the population from diagnostic dental x-ray procedures is the number of radiographic units used for dental purposes. Preliminary data on State and local radiological health programs (*6*) for fiscal year 1967 indicate that there were about 213,800 x-ray machines in the United States of which 100,500 were dental units.

Exposure estimates

From unpublished data of the 1964 survey, average exposures at the skin surface per dental film have been estimated for selected age groups, projections, film speeds and kVp settings (table 3). In 1964, about 53.6 million dental x-ray examinations were performed using 226.7 million films. Periapical[1] and bitewing[2] projections accounted for 99 percent of the film exposures. The average incident skin exposure per film for these techniques is estimated to be 1,144 mR per film (table 3). For individuals 15 years of age and over, the average exposure per film is 1.4 times as high as for children under 15 years; the older group was exposed to almost twice as many films per 100 persons as the younger group. The exposure per film using the periapical technique, which is used twice as frequently as the bitewing, is about 10 percent lower than that for the latter technique.

Table 3. Estimated average exposure to patient per dental film by age, type of projection, film speed and kVp technique, United States, 1964[a]

Category	Estimated average exposure per film[b] (mR at skin entrance)	Percent of films exposed	Annual rate of films exposed per 100 persons in the population
Age of patient:			
Under 15 years	873		78.7
15 years and over	1,220		139.2
All ages	1,144		120.1
Projection:			
Periapical	1,103	67.1	
Bitewing	1,223	32.9	
All projections	1,144	100.0	
Film speed:[c]			
Slow (A)[d]	1,750	5.7	
Intermediate (B&C)	1,633	37.6	
Fast (D)	606	41.7	
Unknown	1,266	15.0	
All film speeds	1,144	100.0	
kVp technique[e]			
45–50	[f]	3.8	
51–65	1,340	58.6	
66–80	1,020	21.1	
81–90	775	16.5	
All kVp	1,144	100.0	

[a] All data in this table are limited to results obtained for the periapical and bitewing projections and is made up from unpublished data from the 1964 x-ray survey by the Division of Radiological Health.

[b] Exposures based on total number of films for which all factors required to calculate exposure at skin entrance were known.

[c] The letters in parentheses for each film speed category represent the classifications as designated in "American Standard Speed Classification for Intraoral Dental Radiographic Film: Diagnostic Grade, ASA Standard (now American National Standards Institute) PH 6.1–1961."

[d] No longer marketed.

[e] Most of the film included in the 51–65 kVp group were exposed using a 65 kVp technique; in the 66–80 group, using a 70 kVp technique; and in the 81–90 group, using a 90 kVp technique.

[f] Sufficient data to prepare valid estimates were not available.

Among dentists who used fast-speed film (D),[3] the average exposure was approximately one-third that for dentists who used slow or intermediate speed films (A, B, C).[3] Approximately 42 percent of the films used in 1964 were classified as fast-speed. The average exposure at the skin surface per film among dentists using the 90 kVp technique[4] was about three-fifths that for the 65 kVp technique.[5] Approximately 59 percent of the films exposed in 1964 were taken with the latter technique.

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[1] The periapical projection is used primarily to study the root of the tooth and the surrounding structures.

[2] The bitewing projection is used primarily to detect caries between the posterior teeth.

[3] See footnote "c" of table 3.

[4] Includes exposures made using the 81–90 kVp technique.

[5] Includes exposures made using the 51–65 kVp technique.

5

An additional observation from the 1964 study was the correlation between the average exposure per film and the dentist's year of graduation from dental school. The average exposure to patients in offices of dentists graduated after 1940 was observed to be almost two-thirds of the average exposure received by patients in offices of dentists graduated prior to that date. This fact may reflect the use of newer x-ray equipment, faster films, better darkroom techniques and special training in good radiation hygiene practice (*5*).

Dose estimates

From available literature, it appears that only a limited amount of experimental work has been done to determine doses from diagnostic dental x-rays. A few studies, however, have measured or estimated doses from dental x rays to various organs or tissues of the body. While some of these doses were originally presented in terms of roentgens, in this report it is assumed that 1 roentgen corresponds to 1 rad or 1 rem in soft tissue (*7*). Table 4 presents absorbed dose estimates from dental radiography compared with certain doses from natural background. The doses for the eye and thyroid are from Richards and Webber (*11*) who used a phantom in which miniature dosimeters were imbedded and determined the dose to various parts of the body from a dental x-ray unit operating at what were considered to be conventional machine settings before 1965.

Table 4. Comparison of absorbed dose estimates from dental radiography with dose estimates from natural background

Organ	Dose	
	Dental x rays	Natural background
Eye (*8*)	23[a] to 27[b] mrads per bitewing[c] examination (2 films) 77[d] to 79[e] mrads per periapical[f] examination (14 films)	
Thyroid (*8*)	30[a] to 44[b] mrads per bitewing[c] examination (2 films) 40[d] to 48[e] mrads per periapical[f] examination (14 films)	
Bone marrow	3 rad mean active mandible bone marrow dose per film (*8*)[g]	
Male gonads	<0.01 to 0.02 mrads per film (*9*)	100 mrad per year (*10*)
Genetically significant dose[h]	<0.01 mrad per year (*9*)	

[a] x-ray machine setting 65 kVp, 10 mA, 3.0 sec for two films.
[b] x-ray machine setting 90 kVp, 10 mA, 1.2 for two films.
[c] Medium-speed film utilized.
[d] x-ray machine setting 65 kVp, 10 mA, 3.4 sec for 14 films.
[e] x-ray machine setting 90 kVp, 10 mA, 1.36 sec for 14 films.
[f] High-speed film utilized.
[g] Based upon an integrated dose of 3g-rad to 25 percent of the active bone marrow of the mandible assuming 1 R skin exposure is equivalent to 1 rad bone marrow dose.
[h] The genetically significant dose (GSD) is an index of radiation received by the genetic pool which determines the progeny of a given population.

It should be noted that the highest gonadal dose for females would be even lower than that for males since it has been estimated this dose is about one-fifth that for males (*12*).

Exposure control

Review of those aspects of dental x-ray exposure for which standards can be developed, along with review of the existing guidance for control or reduction of dental x-ray exposure, suggest the dental x-ray control categories outlined in table 5. The status of standards and compliance in each of these categories is discussed in the table.

In 1962, only 7 States[4] had specific regulations, while some 38 additional States employed recommended standards (*13*). By July 1967, however, all States had some kind of compliance program relating to dental x-ray equipment and/or techniques to reduce radiation during dental x-ray examinations. Twenty-six of the State programs may be classified as regulatory, 17 States have voluntary programs and 10 States have a combination of regulatory and voluntary programs (*6*). Although all States include guides for filtration and collimation, the minimum requirements for these and other guides, standards and regulations vary from State to State.

Approximately 91 percent of the estimated 100,500 dental x-ray units in the United States had been registered by July 1967 by the 47 States[4] with registration programs (*6*). This is a significant increase from the 22,550 units that had been registered by July 1962 in 18 States (*13*).

Before 1960, less than 25 percent of the x-ray machines surveyed met the minimum requirements for filtration and collimation (*13*). By the end of fiscal 1967, approximately 89 percent of the estimated 100,500 dental units had been inspected, at least once, by the States and at least 73 percent of all units were in full compliance with the respective State regulations. During fiscal year 1967, 5,322 dental machines were brought into compliance.

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[4] State figures include the District of Columbia, Puerto Rico and the Virgin Islands.

Table 5. Status of dental x-ray exposure control categories

Control categories	Status
Basic radiation protection guidance	All groups concerned with providing guidance for minimizing radiation from man-made sources (*14–19*) have pointed out that exposure from x rays may have deleterious genetic and/or somatic effects. They stress that all unnecessary exposure from incremental radiation should be avoided and recommend that the benefits versus the possible risks to the patient should always be considered. The basic exposure guidance has stressed keeping exposure to x rays as low as possible through control of all physical variables and advised the practitioner to use the minimum radiation, in his judgment, consistent with the benefit to the patient (*20–23*).
Equipment, design and operation	Primary emphasis has been directed towards studying each aspect of the x-ray machine in order to make recommendations for minimizing the exposure to the patient. Also, as has been pointed out, there has been a progressive effort by the State governments since 1960 to survey the physical characteristics of the machines and to followup these surveys to insure that the corrections were made and to resurvey for continued checks on compliance.
Film utilization	The use of fast film and strict adherence to complete development techniques for developing and processing is one of the areas which will keep the radiation applied to the patient to the minimum consistent with adequate dental practices (*23*). However, information is not readily available on the use of fast-speed films and information is not available on a nationwide basis about film developing and processing techniques used in dental offices.
Patient protection (diagnostic procedures)	Implementation of procedures such as use of leaded rubber aprons, limited field sizes and adequate filtration will lower the extraneous dose to other parts of the body while the area under study receives the minimum radiation necessary to produce a good quality radiographic image (*18*). No data are available on a nationwide basis indicating the number of dentists who use recommended procedures other than filtration and collimation. Exposures of children and pregnant women should be restricted to an absolute minimum (*22*).
Training of dentists or dental auxiliary personnel	No current summary of data for the country is available regarding the number of dental auxiliary personnel or dentists who have received special instruction in x-ray protection procedures, however, one State, Oregon, requires dental auxiliary personnel to pass an examination on radiation hygiene practice (*24*). All dentists should continue their education in radiology as well as other areas of dental practice (*18*).

Sufficient recommendations for each dental x-ray control category exist which, if accepted, would lead to a substantial reduction in exposure and yet not interfere with the exercise of clinical judgment of the practitioner. The regular inspection of dental x-ray units and follow-up surveys of units that did not meet the minimum standards for filtration and collimation have resulted in a major reduction of patient x-ray exposure. An even greater reduction of x-ray exposure would be expected if minimal State standards were devised to include optimum darkroom and film techniques and possibly special training of dental auxiliary personnel in good radiation hygiene practices and film processing.

Recommendations

The following activities have potential for further reducing exposure to the patient from diagnostic dental x-rays or in providing further definition of exposure from this radiation source:

1. Development of a uniform standard with criteria which specify the use of dental x-ray equipment and operational procedures that produce a minimum amount of patient radiation for a given examination;
2. extension of minimum standards of all States to include required special instruction of dentists and auxiliary personnel;

3. continued surveys, documentation and corrective follow-up of the physical characteristics of x-ray equipment by State and Federal agencies to minimize radiation exposure from dental radiography;
4. further clarification of dose estimates either by physical measurements or suitable mathematical models; and
5. a survey of trends in dental public health that may affect the frequency and number of x-ray examinations required to maintain good dental health.

Acknowledgements

Radiation exposure overviews are prepared through a cooperative effort by the Divisions and Offices of the Bureau of Radiological Health which are concerned with various aspects of the definition and control of the radiation exposure source under study, and coordinated by the Office of Criteria and Standards. The following individuals prepared the report: Anne G. Berger (deceased), Warren A. Brill, William H. Oates, Jr., and Marvin Rosenstein, Office of Criteria and Standards, with technical assistance from Ray W. Alcox, D.D.S., Division of Medical Radiation Exposure, and James J. Laubham, Jr., D.D.S., Division of Biological Effects.

REFERENCES

(*1*) PASTERNACK, B. S. and M. B. HELLER. Radiation dose to the population of New York City from medical diagnostic radiology. Final progress report to USPHS, Contract No. PH 86-65-24 (November 1966).

(*2*) HADDON, W., JR. and H. MORGAN. Frequency of medical x-ray examinations in Monroe County, New York. Public Health Rep 80:515–525 (June 1965).

(*3*) IZENSTARK, J. L. and W. LAFFERTY. Population estimates and surface and gonadal exposure from medical x-ray use in New Orleans 1962–1963. Final Report, Contract No. PH 86-65-28 (May 1967).

(*4*) HADDON, W., JR., J. P. CARLOS and D. B. AST. Frequency of dental x-ray examinations in a New York County. Public Health Rep 77:525–532 (June 1962).

(*5*) GITLIN, J. N. and P. S. LAWRENCE. Population exposure to x-rays 1964. A report on the Public Health Service x-ray exposure study, PHS Publication No. 1519. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1966).

(*6*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH, COMPLIANCE AND CONTROL BRANCH. Report of State and Local Radiological Health Programs for Fiscal Year 1967, PHS CCB-68-2 (July 1968).

(*7*) UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. General Assembly, Official Records: Seventeenth Session, Supplement No. 16 (A/5216), New York (1962).

(*8*) U.S. CONGRESS. Hearings before the Joint Committee on Atomic Energy, 89th Congress, Second Session, Proposed legislation relating to uniform record keeping and workmen's compensation coverage for radiation workers (H.R. 16920 and S. 3722) Appendix 21, p. 817–820 (September 1966).

(*9*) PUBLIC HEALTH SERVICE, BUREAU OF RADIOLOGICAL HEALTH. Population Dose from X-Rays, United States, 1964, PHS Publication No. 2001. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (October 1969).

(*10*) UNITED NATIONS SCIENTIFIC COMMITTEE ON THE EFFECTS OF ATOMIC RADIATION. Report of the United Nations Scientific Committee on the Effects of Atomic Radiation. General Assembly, Official Records, Twenty-first Session, Supplement No. 14 (A/6314) New York (1966).

(*11*) RICHARDS, A. G. and R. L. WEBBER. Dental x-ray exposure of sites within the head and neck. Oral Surg Oral Med Oral Path 18:752–756 (December 1964).

(*12*) STANFORD, R. W. and J. VANCE. The quantity of radiation received by the reproductive organs of patients during routine diagnostic x-ray examination. Brit J Radiol 28:266–273 (May 1955).

(*13*) DIVISION OF RADIOLOGICAL HEALTH, STATES ASSISTANCE BRANCH. Report of State and Local Radiological Health Programs for Fiscal Year 1964, PHS SAB DOC 460-1-65 (May 1965).

(*14*) INTERNATIONAL COMMISSION ON RADIOLOGICAL PROTECTION. Recommendation of the International Commission on Radiological Protection, Report No. 6. Pergamon Press, New York, N.Y. (1964).

(*15*) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*16*) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical x-ray protection up to three million volts, National Bureau of Standards Handbook 76 (February 1961).

(*17*) AMERICAN PUBLIC HEALTH ASSOCIATION, SUBCOMMITTEE ON RADIOLOGICAL HEALTH. Ionizing Radiation. Prepared under the Direction of the Subcommittee on Radiological Health and Approved by the Program Area Committee on Environmental Health and the Radiological Health Section Council of the APHA, New York (1966).

(*18*) AMERICAN DENTAL ASSOCIATION, COUNCIL ON DENTAL MATERIALS AND DEVICES, COUNCIL ON DENTAL RESEARCH. Recommendations in radiation hygiene and practice. J Amer Dent Assoc 76:363–365 (February 1968).

(*19*) BARR, J. H., R. E. SILHA, and A. G. RICHARDS. The effective use of x-ray radiation in dentistry. Oral Surg Oral Med Oral Path 16:294–304 (March 1963).

(*20*) NEW JERSEY STATE DEPARTMENT OF HEALTH. Recommendations for reducing occupational and patient radiation exposures in the dental profession, M2453. Trenton, N.J.

(*21*) RICHARDS, A. G. New method for reduction of gonadal irradiation of dental patients. J. Amer Dent Assoc 65:1 (1962).

(*22*) CHAMBERLAIN, R. H. A practical manual on the medical and dental use of x-rays with control of radiation hazards. The American College of Radiology (1958).

(*23*) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radiation Protection for Dentist and Patient, PHS Publication No. 885. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1962).

(*24*) STATE OF OREGON. Oregon Revised Statutes, Chapter 818, Sect. 10–130 (January 1964).

Evaluation of Emissions from Radium Dial Watches

Herbert F. Klein, Earl W. Robinson, Royce L. Gragg, and James W. Rolofson[1]

Seventeen U.S. Army surplus radium-dial pocket watches were examined for radium content. The absorbed dose rates at the surface of the watches were measured and found to vary from 23.8 to 36.1 mrad/h-μCi. A simulated radium dial watch was constructed and used to estimate absorbed dose rates to various parts of the human body.

During 1968, 3,154 radium-activated, self-luminous pocket watches were released by the U.S. Army through government surplus channels to certain State surplus property agencies. In March 1968, the Bureau of Radiological Health (BRH) (then the National Center for Radiological Health) notified the radiological health agencies of these States that this distribution had been made and recommended that "these watches either not be distributed or be distributed with restrictions." This action was based on preliminary measurements of the radium content of the watches, the IAEA recommendation that radium not be used in pocket watches (*1*), and the public health objective of reducing unnecessary exposure. Subsequently, 1,700 of the watches were removed from State and Federal surplus channels and shipped to the Bureau of Radiological Health for disposal as radioactive waste (*2*).

A study was conducted by the Division of Medical Radiation Exposure, BRH, to evaluate the potential external radiation exposure from the use of these radium-activated self-luminous pocket watches. Measurements were made of (1) the radium content of a sample from the surplus watches, (2) surface absorbed dose rate from a part of the sample group, and (3) absorbed dose to various anatomical sites within a human phantom using a high radium content, simulated pocket watch.

Radium content of watches

The radium content of a sample of 17 watches was measured (table 1). A NaI detector and multichannel analyzer were used to compare the radio-

Table 1. Radium content of watches

Watch number	Measured content (μCi)
1	1.39
2	1.36
3	1.35
4	1.30
5	1.16
6	1.09
7	1.07
8	1.07
9	1.04
10	1.02
11	.95
12	.91
13	.85
14	.82
15	.78
16	.68
17	.60
Average	1.03

---

[1] Messrs Klein, and Gragg are on the staff of the Division of Electronic Products; Mr. Robinson is on the staff of the Division of Medical Radiation Exposure; and Mr. Rolofson is on the staff of the Division of Biological Effects; Bureau of Radiological Health, Environmental Control Administration, Consumer Protection and Environmental Health Service, Department of Health, Education, and Welfare.

activity of the watches with a standard constructed by removing the hands and dial plate from a sample watch and taping a calibrated 9.73 μCi radium-cell-loaded tube behind the center of the crystal. The intact watches were covered with 1 mm of lead, which closely approximates the 0.5 mm platinum-iridium filtration of the calibrated radium cell. All watches were counted at 9.75 inches from the center of the NaI crystal; counts were integrated under the 0.61 MeV peak of bismuth-214 after subtracting the background.

Surface absorbed dose measurements

In order to measure the absorbed dose rate at the surface of the watches, a paraffin phantom (figure 1) was constructed with recesses for the watch and for 5 lithium fluoride dosimeters. The phantom was constructed of a tissue-equivalent mix (*3*) and was designed to approximate the backscatter of the human body. Each dosimeter consisted of a preannealed hot-pressed TLD-100 lithium fluoride rod in a number 5 gelatin capsule.

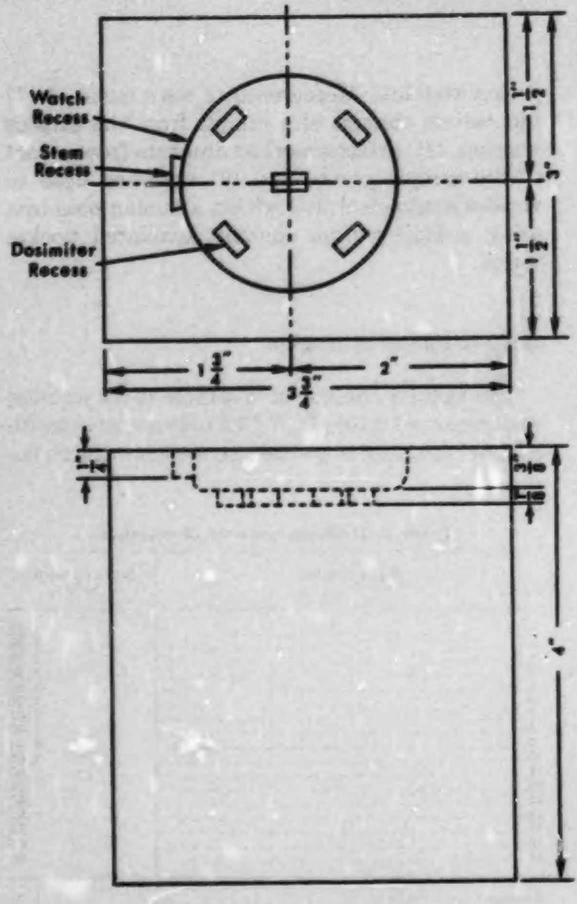

Figure 1. Paraffin phantom

Eight of the watches listed in table 1 were selected for these measurements. The watch under test was placed, crystal down, in the ⅜-inch deep recess in the phantom. The phantom was next inverted to place the dosimeters closer to the watch face and to produce a more uniform dosimeter-crystal orientation in each dosimeter location. Dosimeters were exposed to the emissions from the watch for approximately 25 hours during which time the watch was running. Doses were then measured using a dose-response relationship determined after each annealing. Additional measurements were made after placing 1 millimeter of lead between the watch and the dosimeters. The average dose rate was calculated from the doses to the 5 dosimeters (table 2). For each watch, the maximum dose measured by a single TLD was within a range of 2.1–3.6 times the minimum except for one watch whose range was greater.

Table 2. Average surface absorbed dose rate

Watch number	Radium content (μCi)	Dose rate at crystal		
		Filtered (1 mm Pb) (mrad/h)	Unfiltered (mrad/h)	Unfiltered (mrad/h-μCi)
2	1.36	3.48	49.1	36.1
3	1.35	3.24	42.9	31.8
4	1.30	3.18	35.1	27.0
6	1.09	2.60	30.0	27.5
7	1.07	2.78	29.3	27.4
11	.95	2.42	22.8	24.0
12	.91	2.37	27.8	30.5
13	.85	2.35	20.2	23.8
Average				28.5

The unfiltered measurements include exposure to beta particles. The lithium fluoride response per rad of beta radiation is equal to that from gamma radiation in the beta and gamma energy range of radium and its daughters. Therefore, the difference between the unfiltered and the filtered absorbed dose rate can be considered as the beta and soft gamma absorbed dose rate, since 99.9 percent of the beta particles less than 2 MeV are absorbed by the 1 mm lead filter used, and more than 40 percent of the gamma photons of less than 0.3 MeV are absorbed.

Table 3. Absorbed dose distribution within phantom

Body organ	Absorbed dose rate from simulated watch (mrad/h)	Calculated absorbed dose rate per μCi (μrad/h)	Annual absorbed dose per μCi for a 16 hour day (mrad)
Testes (average R + L)	42.5	10.3	60.0
Uterus (P)[a]	74.5	18.0	105.0
Ovary (R)[a]	132.3	32.0	187.0
(L)	66.2	16.0	93.5
Bladder (A)	67.8	16.4	96.0
Spine L-3 (P)	132.0	32.0	187.0
Gall bladder (A)	240.0	58.2	340.0
Kidney (L)	36.0	8.7	51.0
Colon, transverse (A)	113.0	27.4	160.0
Spine T-11 (P)	16.0	3.9	22.7
Liver (P)	20.0	4.9	28.3
Spine T-6 (P)	6.0	1.5	8.5
Lung, superior lobe			
(R—P)	7.2	1.7	10.2
(L—P)	4.9	1.2	6.9
Lung, superior lobe			
(R—A)	10.4	2.5	14.7
(L—A)	5.1	1.2	7.2
Body of sternum (A)	8.1	2.0	11.4
Spine C-7 (P)	3.0	0.7	4.3
Thyroid gland (A)	3.3	0.8	4.7
Sternum (superficial)	6.1	1.5	8.6
Thyroid (inferior to laryngeal prominence)	3.0	0.7	4.3
Spine C-5 (P)	2.9	0.7	4.1
Thyroid (parathyroid L)	2.6	0.6	3.7
(parathyroid R)	2.6	0.6	3.7

[a] These data are included only for anatomical reference of "dose" distribution, since the assumption is made that women do not carry pocket watches.

(P)-Posterior
(A)-Anterior
(L)-Left side
(R)-Right side

The unfiltered surface absorbed dose rate per microcurie of radium is also shown in table 2. This dose rate varies from 23.8–36.1 mrad/h-μCi. The variation is attributable to differences in the distribution of the radium on the various watches in respect to the position of the five dosimeters.

Estimation of absorbed dose to gonads and other anatomical sites

The absorbed dose rate to remote sites of the human body from any the sample pocket watches would be relatively small in terms of the detection capability of TLD rods. Therefore, a simulated radium-activated watch of higher activity was required to estimate the absorbed dose to these sites using a sectioned human phantom. This watch was prepared by removing the hands and dial plate from a sample watch and attaching a platinum-encapsulated radium-226 needle at each of the 2:00, 4:00, 7:00, and 10:00 o'clock positions behind the crystal. Total radium content of the needles was 4.13 mCi.

TLD rods were inserted in the various sites within the phantom, and the watch was placed with its crystal facing inward on the crest of the phantom's iliac. After 6 hours, the TLD rods were removed and their absorbed dose measured. The absorbed dose rate was then calculated for each site (table 3). Annual absorbed dose rates normalized for a watch content of 1 μCi of radium for 16 hours a day were then calculated and also appear in table 3.

Conclusions

The radium content of the watches studied ranged from 0.60 to 1.39 μCi with an average of approximately 1 μCi. The data show that a watch containing 1 microcurie of radium would expose the gonads of a male to an annual dose of 60 millirads if worn for 16 hours daily while the skin directly under the face of the watch would receive an average dose of 165 rads.

REFERENCES

(1) INTERNATIONAL ATOMIC ENERGY AGENCY. Radiation protection standards for radioluminous timepieces. Recommendations of the European Nuclear Energy Agency and the International Atomic Energy Agency, IAEA Safety Series No. 23, Vienna (1967).

(2) ROBINSON, E. W. The use of radium in consumer products, MORP 68-5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20204 (November 1968).

SECTION I. MILK AND FOOD

Milk Surveillance, September 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both

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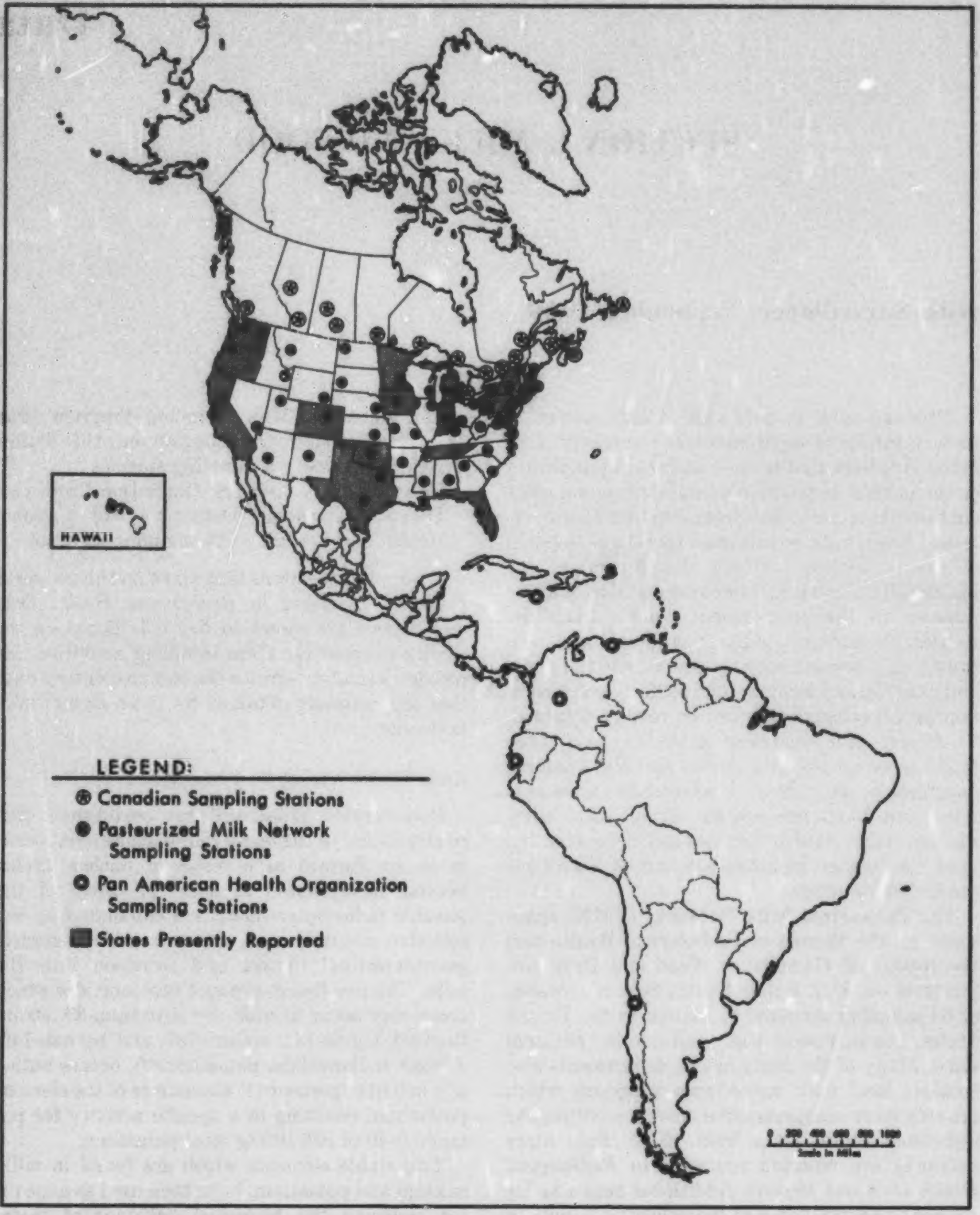
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Health Organization Sampling Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in December 1968, with 37 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131 and cesium-137. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 18 participated in the experiment.

In general, the results for iodine-131 and cesium-137 are encouraging, but the results for strontium-89 and strontium-90 need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

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Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors of precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1–5 pCi/liter for levels <50 pCi/liter; 5–10% for levels ≥50 pCi/liter
Strontium-90	1–2 pCi/liter for levels <20 pCi/liter; 4–10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4–10 pCi/liter for levels <100 pCi/liter; 4–10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges; 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Nuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a one or two year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maxi-

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]61,000
Cesium-137	Whole body			[c]720,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

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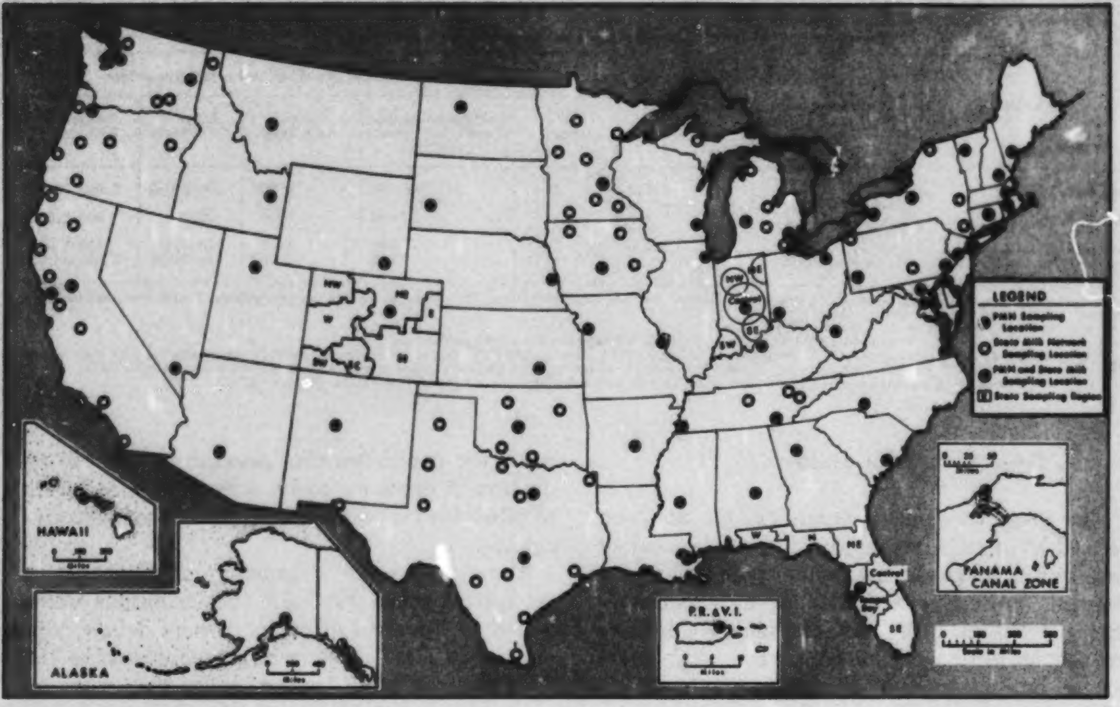

Figure 2. State and PMN milk sampling locations in the United States

mum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-89, strontium-90, iodine-131, and cesium-137 for September 1969 and the 12-month period, October 1968–September 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium-140 data have been omitted from table 3 since levels at the great majority of the stations for September 1969 were below the respective practical reporting levels with the exception of Erie, Pa., 17 pCi/liter, 1 sample.

Table 3. Concentration of radionuclides in milk for September 1969 and 12-month period, October 1968 through September 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)							
			Strontium-89		Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:										
Ala:	Montgomery[c]	P	0 (2)	1	5 (2)	6	0 (4)	0	11 (4)	11
Alaska:	Palmer[c]	P	0	0	6	6	0 (4)	0	0 (4)	8
Ariz:	Phoenix[c]	P	0	0	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	3 (2)	1	15 (2)	18	0 (5)	0	14 (5)	18
Calif:	Sacramento[c]	P	0	0	0	2	0 (4)	0	0 (4)	1
	San Francisco[c]	P	0	0	2	2	0 (4)	0	0 (4)	0
	Del Norte	P	11	1	18	19	0	0	17	18
	Fresno	P	0	0	0	0	0	0	5	1
	Humboldt	P	0	2	4	5	0	0	8	8
	Los Angeles	P	0	0	0	0	0	0	0	1
	Mendocino	P	0	0	2	3	0	0	2	1
	Sacramento	P	0	0	3	3	0	0	2	1
	San Diego	P	0	0	0	0	0	0	1	1
	Santa Clara	P	0	0	0	0	0	0	6	3
	Shasta	P	0	0	4	3	0	0	5	4
	Sonoma	P	0	0	3	2	0	0	4	0
Colo:	Denver[c]	P	0	3	6	5	0 (4)	0	0 (4)	2
	West	R	(d)		(d)		(e) (12)	(e)	(e) (12)	(e)
	Northeast	R	(d)		(d)		(e) (3)	(e)	(e) (3)	(e)
	East	R	(d)		(d)		(e)	(e)	(e)	(e)
	Southeast	R	(d)		(d)		(e)	(e)	(e) (3)	(e)
	South Central	R	(d)		(d)		NS	(e)	NS	(e)
	Southwest	R	(d)		(d)		(e)	(e)	(e)	(e)
	Northwest	R	(d)		(d)		(e)	(e)	(e) (2)	(e)
Conn:	Hartford[c]	P	6	3	7	8	0 (3)	0	10 (3)	12
	Central	P	0	0	8	7	0 (4)	0	12 (4)	11
Del:	Wilmington[c]	P	7	3	6	8	0 (4)	0	3 (4)	7
D.C:	Washington[c]	P	3 (2)	1	6 (2)	8	0 (4)	0	4 (4)	4
Fla:	Tampa[c]	P	4 (2)	0	5 (2)	7	0 (4)	0	61 (4)	60
	West	R	(d)		11	12	0	0	22	22
	North	R	(d)		10	14	0	0	23	25
	Northeast	R	(d)		9	8	0	0	66	66
	Central	R	(d)		10	8	0	0	58	57
	Tampa Bay area	R	(d)		9	8	0	1	62	64
	Southeast	R	(d)		8	9	0	0	98	98
Ga:	Atlanta[c]	P	0 (2)	0	8 (2)	10	0 (4)	0	24 (4)	19
Hawaii:	Honolulu[c]	P	0 (4)	0	3 (4)	3	0 (4)	0	0 (4)	0
Idaho:	Idaho Falls[c]	P	0	1	5	5	0 (5)	0	3 (5)	7
Ill:	Chicago[c]	P	0	2	6	8	0 (5)	0	12 (5)	10
Ind:	Indianapolis[c]	P	0	0	7	8	0 (5)	0	1 (5)	6
	Northeast	P	0	0	10	12	0	0	20	10
	Southeast	P	0	0	10	8	0	0	10	10
	Central	P	0	0	8	10	0	0	10	10
	Southwest	P	0	0	12	10	0	0	10	10
	Northwest	P	0	0	10	10	0	0	20	20
Iowa:	Des Moines[c]	P	0	1	6	6	0 (4)	0	0 (4)	3
	Iowa City	P	NS		NS		NS		NS	
	Des Moines	P	NS		NS		NS		NS	
	Spencer	P	NS		NS		NS		NS	
	Fredericksburg	P	NS		NS		NS		NS	
Kans:	Wichita[c]	P	7	2	5	7	0 (5)	0	0 (5)	2
Ky:	Louisville[c]	P	3 (2)	2	9 (2)	10	0 (5)	0	2 (5)	6
La:	New Orleans[c]	P	0 (2)	2	15 (2)	17	0 (3)	0	19 (3)	20
Maine:	Portland[c]	P	0	0	14	12	0 (4)	0	24 (4)	25
Md:	Baltimore[c]	P	4 (2)	1	7 (2)	9	0 (5)	1	3 (5)	7
Mass:	Boston[c]	P	0	1	11	11	0 (5)	0	21 (5)	21
Mich:	Detroit[c]	P	0	0	9	8	0 (5)	0	7 (5)	9
	Grand Rapids[c]	P	0	0	9	10	0 (5)	0	15 (5)	14
	Bay City	P	(d)		NS	NA	NS	(e)	NS	11
	Charlevoix	P	(d)		8	10	(e) (4)	(e)	24 (4)	17
	Detroit	P	(d)		5	3	(e) (3)	(e)	7 (3)	5
	Grand Rapids	P	(d)		5	7	(e) (5)	(e)	14 (5)	11
	Lansing	P	(d)		7	6	(e) (2)	(e)	14 (2)	9
	Marquette	P	(d)		8	9	(e) (3)	(e)	24 (3)	23
	Monroe	P	(d)		5	4	(e) (3)	(e)	0 (3)	1
	South Haven	P	(d)		NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	0	2	10	10	0 (5)	0	10 (5)	11
	Bemidji	P	(d)		17	17	0	0	20	24
	Mankato	P	(d)		9	8	0	0	0	0
	Rochester	P	(d)		8	9	0	0	0	0
	Duluth	P	(d)		17	19	0	0	25	25
	Worthington	P	(d)		7	8	0	0	0	0
	Minneapolis	P	(d)		12	12	0	0	0	0
	Fergus Falls	P	(d)		11	9	0	0	0	0
	Little Falls	P	(d)		9	10	0	0	0	12
Miss:	Jackson[c]	P	3 (2)	1	11 (2)	13	0 (4)	0	15 (4)	16
Mo:	Kansas City[c]	P	0	4	8	7	0 (3)	0	1 (3)	2
	St. Louis	P	8	2	7	8	0 (4)	0	0 (4)	3
Mont:	Helena[c]	P	0	1	5	5	0 (5)	0	3 (5)	6
Nebr:	Omaha[c]	P	0	3	5	6	0 (5)	0	0 (5)	2

See footnotes at end of table.

Table 3. Concentration of radionuclides in milk for September 1969 and 12-month period, October 1968 through September 1969—Continued

Sampling location	Type of sample[a]	Strontium-89 Monthly average[b]	Strontium-89 12-month average	Strontium-90 Monthly average[b]	Strontium-90 12-month average	Iodine-131 Monthly average[b]	Iodine-131 12-month average	Cesium-137 Monthly average[b]	Cesium-137 12-month average
UNITED STATES:—Continued									
Nev: Las Vegas[c]	P	0	0	0	1	0 (5)	0	0 (5)	0
N.H: Manchester[c]	P	0	0	6	9	0 (5)	0	15 (5)	22
N.J: Trenton[c]	P	0	0	9	9	0 (4)	0	1 (4)	8
N.Mex: Albuquerque[c]	P	0	0	3	2	0 (5)	0	3 (5)	1
N.Y: Buffalo[c]	P	0 (2)	0	7 (2)	7	0 (4)	0	4 (4)	9
New York City[c]	P	0	0	12	10	0 (5)	0	11 (5)	13
Syracuse[c]	P	0	0	8	8	0 (5)	0	13 (5)	9
Albany	P	0	0	0	6	0 (3)	0	0 (3)	0
Buffalo	P	0	0	0	5	0	0	0	0
Massena	P	5	0	2	10	0 (2)	0	0 (2)	0
Newburgh	P	10	0	0	10	0	0	0	0
New York City	P	0	0	9	11	0 (4)	0	0 (3)	0
Syracuse	P	0	0	7	7	0 (2)	0	0 (2)	0
N.C: Charlotte[c]	P	0 (2)	1	10 (2)	14	0 (5)	0	9 (5)	12
N.Dak: Minot[c]	P	14	6	8	10	0 (5)	0	10 (5)	12
Ohio: Cincinnati[c]	P	0	0	9	8	0 (4)	0	0 (4)	3
Cleveland[c]	P	0	0	9	8	0 (4)	0	4 (4)	7
Okla: Oklahoma City[c]	P	4 (2)	1	7 (2)	8	0 (5)	0	11 (5)	10
Oklahoma City	P	NS		NS		NS		NS	
Enid	P	NS		NS		NS		NS	
Tulsa	P	NS		NS		NS		NS	
Lawton	P	NS		NS		NS		NS	
Ardmore	P	NS		NS		NS		NS	
Ore: Portland[c]	P	0	2	9	7	0 (4)	0	9 (4)	7
Baker	P	(d)		0	2	(e)	(e)	(e)	8
Coos Bay	P	(d)		0	6	(e)	(e)	(e)	11
Eugene	P	(d)		0	4	(e)	(e)	(e)	8
Medford	P	(d)		0	2	(e)	(e)	33	10
Portland composite	P	(d)		0	3	(e)	(e)	(e) (4)	6
Portland local	P	(d)		2	4	(e)	(e)	(e) (4)	10
Redmond	P	(d)		0	2	(e)	(e)	(e)	5
Tillamook	R	(d)		0	5	(e)	(e)	21	21
Pa: Philadelphia[c]	P	0	0	10	9	0 (4)	0	3 (4)	5
Pittsburgh[c]	P	0	0	11	12	0 (5)	0	10 (5)	8
Dauphin	P	(d)		6	7	0	1	19	14
Erie	P	(d)		11	11	26	5	19	18
Philadelphia	P	(d)		10	9	0	0	5	12
Pittsburgh	P	(d)		11	10	0	1	14	16
R.I: Providence[c]	P	0	0	10	9	0 (5)	0	15 (5)	17
S.C: Charleston[c]	P	0 (2)	0	10 (2)	11	0 (5)	0	25 (5)	24
S.Dak: Rapid City[c]	P	9	5	8	8	0 (5)	0	3 (5)	6
Tenn: Chattanooga[c]	P	4	2	9 (2)	11	0 (5)	0	10 (5)	13
Memphis[c]	P	0	1	9 (2)	9	0 (4)	0	0 (4)	6
Chattanooga	P	0	4	13	13	0 (4)	0	15	15
Clinton	P	0	1	12	15	0 (2)	1	15	14
Knoxville	P	0	1	10	10	0	0	13	8
Nashville	P	NS	3	NS	9	NS	0	NS	5
Tex: Austin[c]	P	4 (2)	1	0 (2)	2	0 (2)	0	0 (2)	4
Dallas[c]	P	3 (2)	1	5 (2)	7	0 (5)	0	5 (5)	7
Amarillo	R	(d)		5	4	0	0	0	0
Corpus Christi	R	(d)		NS	4	NS	0	NS	0
El Paso	R	(d)		NS	2	NS	0	NS	0
Fort Worth	R	(d)		NS	6	NS	0	NS	0
Harlingen	R	(d)		2	2	0	0	0	0
Houston	R	(d)		NS	7	NS	0	NS	19
Lubbock	R	(d)		NS	3	NS	0	NS	0
Midland	R	(d)		NS	2	NS	0	NS	0
San Antonio	R	(d)		2	3	0	0	0	0
Texarkana	R	(d)		NS	11	NS	0	NS	10
Uvalde	R	(d)		NS	1	0	0	NS	0
Wichita Falls	R	(d)		NS	6	0	0	0	5
Utah: Salt Lake City[c]	P	0	1	5	4	0 (5)	0	6 (5)	7
Vt: Burlington[c]	P	0	0	7	8	0 (5)	0	18 (5)	14
Va: Norfolk[c]	P	0 (2)	0	11 (2)	10	0 (4)	0	9 (4)	7
Wash: Seattle[c]	P	0	1	8	8	0 (4)	0	13 (4)	15
Spokane[c]	P	0	1	6	6	0 (5)	0	6 (5)	5
Benton County	R	(d)		0	1	0	0	12	5
Franklin County	R	NS		NS	1	NS	0	NS	0
Sandpoint, Idaho	R	(d)		10	11	0	0	38	28
Skagit County	R	(d)		10	7	0	0	36	14
W.Va: Charleston[c]	P	0 (2)	1	8 (2)	9	0 (4)	0	0 (4)	8
Wis: Milwaukee[c]	P	0	0	6	7	0 (4)	0	7 (4)	12
Wyo: Laramie[c]	P	6	1	3	5	0 (4)	0	1 (4)	10

See footnotes at end of table.

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Table 3. Concentration of radionuclides in milk for September 1969 and 12-month period, October 1968 through September 1969—Continued

Sampling location	Type of sample[a]	Strontium-89 Monthly average[b]	Strontium-89 12-month average	Strontium-90 Monthly average[b]	Strontium-90 12-month average	Iodine-131 Monthly average[b]	Iodine-131 12-month average	Cesium-137 Monthly average[b]	Cesium-137 12-month average
CANADA:									
Alberta: Calgary	P	(d)		9	8	(d)		15	16
Edmonton	P	(d)		6	7	(d)		15	15
British Columbia: Vancouver	P	(d)		9	12	(d)		34	36
Manitoba: Winnipeg	P	(d)		8	9	(d)		21	25
New Brunswick: Fredericton	P	(d)		15	14	(d)		16	19
Newfoundland: St. Johns	P	(d)		29	18	(d)		54	37
Nova Scotia: Halifax	P	(d)		10	10	(d)		20	20
Ontario: Ft. William	P	(d)		11	16	(d)		28	21
Ottawa	P	(d)		8	9	(d)		16	16
Sault Ste. Marie	P	(d)		13	16	(d)		34	31
Toronto	P	(d)		3	5	(d)		9	13
Windsor	P	(d)		6	6	(d)		6	12
Quebec: Montreal	P	(d)		7	9	(d)		22	18
Quebec	P	(d)		11	11	(d)		28	27
Saskatchewan: Regina	P	(d)		8	7	(d)		15	14
Saskatoon	P	(d)		10	8	(d)		15	14
CENTRAL AND SOUTH AMERICA:									
Columbia: Bogota	P	0	10	1	1	0	0	0	1
Chile: Santiago	P	0	4	2	0	0	0	10	1
Ecuador: Guayaquil	P	0	2	0	0	0	0	0	0
Jamaica: Montego Bay	P	10	3	7	5	0	0	260	100
Venezuela: Caracas	P	0	2	3	1	0	0	0	0
Canal Zone: Cristobal[c]	P	0 (2)	2	1 (2)	1	0 (5)	0	11 (5)	13
Puerto Rico: San Juan[c]	P	3 (2)	1	2 (2)	4	0 (4)	0	0 (4)	7
PMN Network average		2	1	7	8	0	0	7	10

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado-25 pCi/liter
Michigan-14 pCi/liter
Oregon-15 pCi/liter

Cesium-137: Colorado-25 pCi/liter
New York-30 pCi/liter
Washington-15 pCi/liter

[f] This entry gives the average radionuclide concentration for the PHS Pasteurized Milk Network stations denoted by footnote c.
NA, no analysis.
NS, no sample collected.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Iodine-131 monthly averages were all below the practical reporting level with the exception of Erie, Pa., 26 pCi/liter, 1 sample, and Clinton, Tenn. 5 pCi/liter, 2 samples.

Strontium-89 monthly averages ranged from 0 to 14 pCi/liter in the United States for the month of September 1969 and the highest 12-month average was 6 pCi/liter (Minot, N. Dak.) representing 0.3 percent of the recommended guide (table 1). Strontium-90 monthly averages ranged

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from 0 to 18 pCi/liter for the month of September 1969 and the highest 12-month average was 19 pCi/liter (Del Norte, Calif., and Duluth, Minn.) representing 9.5 percent of the recommended guide (table 1). Cesium-137 monthly averages ranged from 0 to 98 pCi/liter in the United States for the month of September 1969 and the highest 12-month average was 96 pCi/liter (southeast Florida), representing 2.7 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica.

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California State Department of Health

Radiological Health Section
Division of Air, Occupational, and
Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National
Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological
Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).

(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, strontium-89, and strontium-90 measurements in milk, December 1968, Technical Experiment 68-MAKU-2. Analytical Quality Control Service, Bureau of Radiological Health, Rockville, Md. 20851 (December 1968.)

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(9) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Fla. Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows.

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	January–June 1968	November 1968
Strontium-90 in Tri-City Diets	August–December 1968	December 1969

1. Radionuclides in Institutional Diet Samples April June 1969

Bureau of Radiological Health

The determination of radionuclide concentrations in the diet constitutes an important element of an integrated program of environmental radiological surveillance and assessment. In recognition of the potential significance of the diet in contributing to total environmental radiation exposures, the Public Health Service initiated its Institutional Total Diet Sampling Network in 1961. This program is administered by the Bureau of Radiological Health with the assistance of the Bureau of Compliance, Food and Drug Administration (*1*).

The program was designed to provide estimates of the dietary intake of radionuclides in a selected population group ranging from children to young adults of school age. Initially, the program was conducted at eight institutions; as of January 1965, its scope had increased to boarding schools or institutions in 50 municipalities. These institutions ranged from financially well-to-do boarding schools to orphanages with severe economic limitations.

Subsequent experience with the diets of school children of various ages indicated that the number of institutions sampled could be selectively reduced. As of July 196[illegible], 21 basic institutions and eight auxiliary institutions distributed geographically as shown in figure 1, were being sampled. Previous results showed that the daily dietary intake of teenage girls and children from 9 to 12 years of age were comparable, while teenage boys consumed 20 percent more food per day (*1, 2*). Consequently, estimates for teenage boys or girls can be calculated on the basis of the dietary intakes of children.

In general, the sampling procedure is the same at each institution. Each sample represents the edible portion of the diet for a full 7-day week, (21 meals plus soft drinks, candy bars, or other in-between snacks) obtained by duplicating the meals of a different individual each day. Drinking water, not included in the samples, is also sampled periodically. Each daily sample is kept frozen until the end of the collection period and is then packed in dry ice and shipped by air express to either the

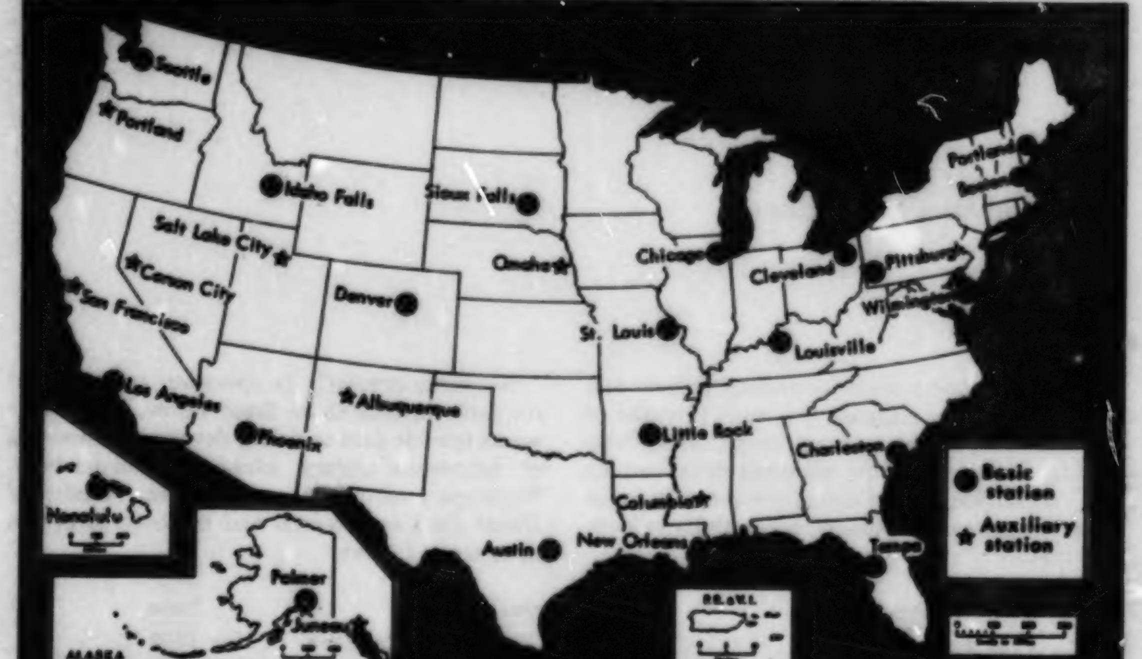
Seattle
Portland
Idaho Falls
Sioux Falls
Salt Lake City
Omaha
Carson City
Denver
San Francisco
Chicago
Cleveland
Pittsburgh
Wilmington
Portland
Boston
St. Louis
Louisville
Los Angeles
Albuquerque
Phoenix
Little Rock
Charleston
Honolulu
Columbia
Austin
New Orleans
Tampa
Palmer
Juneau
ALASKA
PR & VI
Basic station
Auxiliary station

Figure 1. Institutional diet sampling locations as of June 1969

Southwestern Radiological Health Laboratory, Las Vegas, Nev; the Southeastern Radiological Health Laboratory, Montgomery, Ala; or the Northeastern Radiological Health Laboratory, Winchester, Mass. A detailed description of sampling and analytical procedures was presented earlier. (*3*)

Results

Table 1 presents the analytical results for institutional diet samples collected from April through June 1969, for children 9 to 12 years of age. The stable elements, calcium and potassium, are reported in g/kg of diet, and the radionuclide concentrations of these samples reported in pCi/kg

Table 1. Concentration and intake of stable elements and radionuclides in institutional total diets of children (9–12 years of age), April–June 1969

Location of Institution	Month (1969)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Palmer	April[a]	1.21	0.81	0.98	2.0	2.4	0	0	8	9	14	17	0.5	0.6
	May	1.59	.44	.70	1.0	1.6	0	0	6	10	0	0	.3	.5
	June	1.66	.50	.83	1.1	1.7	0	0	3	5	0	0	.5	.8
Ariz: Phoenix	April	1.81	.50	.91	1.3	2.3	0	0	3	5	0	0	.4	.7
	May	1.89	.52	.98	1.4	2.6	0	0	2	5	0	0	.4	.8
	June	1.78	.38	.68	1.3	2.3	0	0	0	0	0	0	.3	.5
Ark: Little Rock	April	1.56	.56	.87	1.4	2.2	NA	NA	8	12	0	0	.7	1.1
	May	1.33	.58	.77	1.9	2.5	NA	NA	7	9	22	29	.6	.8
	June	1.11	.33	.37	1.0	1.1	NA	NA	5	5	12	13	.4	.4
Calif: Los Angeles	April[a]	1.58	.37	.57	1.2	1.9	0	0	0	0	0	0	.4	.6
	May[a]	1.75	.34	.61	.9	1.6	0	0	3	5	0	0	.5	.9
	June	1.58	.50	.79	1.3	2.0	0	0	0	0	0	0	.5	.8
Colo: Denver	April	2.35	.79	.78	1.4	3.3	0	0	7	15	0	0	.7	.6
	May	2.19	.66	.46	1.3	2.8	0	0	6	12	0	0	.7	1.5
	June	NS												
Del: Wilmington	April	2.21	.71	.57	1.6	3.5	NA	NA	5	11	0	0	.7	1.5
	May	NS												
	June	2.31	.65	1.50	1.7	3.9	NA	NA	6	14	19	44	.6	1.4
Fla: Tampa	April	1.19	.49	.58	1.3	1.6	NA	NA	6	7	18	21	.9	1.1
	May	1.26	.57	.72	1.5	1.9	NA	NA	7	9	26	33	.6	.8
	June	1.28	.46	.58	1.4	1.8	NA	NA	6	7	35	45	.8	1.0
Hawaii: Honolulu	April	2.88	.39	1.12	1.4	3.9	0	0	6	16	11	31	.3	.9
	May	2.86	.36	1.03	1.3	3.7	0	0	4	11	0	0	.4	1.1
	June	2.41	.49	1.18	1.4	2.4	0	0	4	10	23	56	.4	1.0
Idaho: Idaho Falls	April[a]	2.21	.99	2.20	1.8	4.0	0	0	7	15	13	29	.5	1.1
	May[a]	1.97	.29	2.54	1.0	3.2	NA	NA	9	18	0	0	.7	1.4
	June[a]	2.10	.98	2.38	1.8	3.8	NA	NA	7	15	0	0	.7	1.5
Ky: Louisville	April	1.89	.79	1.49	1.7	3.1	NA	NA	11	20	0	0	.6	1.1
	May	2.07	.80	1.66	1.7	3.5	NA	NA	9	19	0	0	.5	1.0
	June	1.90	.82	1.56	1.5	2.9	NA	NA	10	19	12	23	.5	1.0
La: New Orleans	April	1.99	.68	1.35	1.7	3.4	0	0	11	23	0	0	.3	.6
	May	2.01	.59	1.19	1.7	3.5	0	0	11	23	0	0	.5	1.0
	June	2.10	.55	1.16	1.5	3.2	0	0	9	20	16	35	.4	.8
Maine: Portland	April	1.70	.84	1.43	1.9	3.2	NA	NA	11	19	31	53	.7	1.2
	May	1.91	.82	1.57	1.8	3.4	NA	NA	13	25	36	69	.5	1.0
	June	1.53	.60	.92	1.8	2.8	NA	NA	12	18	41	63	.5	.8
Mass: Boston	April	2.06	.59	1.23	1.7	3.5	0	0	6	12	17	35	.5	1.0
	May	2.04	.62	1.26	1.8	3.7	0	0	7	14	22	45	.7	1.4
	June	2.13	.64	1.36	1.8	3.8	0	0	10	21	20	43	.7	1.5
Mo: St. Louis	April[a]	2.49	1.42	3.54	1.8	4.5	NA	NA	15	37	0	0	2.3	5.7
	May[a]	2.55	1.38	3.52	1.8	4.6	NA	NA	10	26	0	0	.8	2.0
	June[a]	2.43	1.06	2.58	1.9	4.6	NA	NA	9	22	12	29	.7	1.7
Ohio: Cleveland	April	1.49	.76	1.13	1.9	2.8	NA	NA	7	10	14	21	1.0	1.5
	May	1.56	.66	1.03	1.8	2.8	NA	NA	6	9	0	0	.7	1.1
	June	1.44	.67	.96	1.8	2.6	NA	NA	6	9	0	0	.5	.7
Pa: Pittsburgh	April	2.24	.53	1.19	1.4	3.1	NA	NA	8	18	0	0	.7	1.6
	May	2.26	.55	1.24	1.5	3.4	NA	NA	7	16	0	0	.6	1.4
	June	2.20	.53	1.17	1.5	3.3	NA	NA	8	18	11	24	.6	1.3
S.C.: Charleston	April	1.72	.66	1.14	1.4	2.4	0	0	8	14	17	29	.6	1.0
	May	1.45	.76	1.10	1.6	2.4	0	0	12	17	16	23	.6	.9
	June	1.01	.49	.49	1.4	1.5	0	0	10	10	36	36	.6	.6
S.Dak: Sioux Falls	April	1.39	.75	1.04	1.5	2.1	NA	NA	7	10	0	0	.9	1.3
	May	1.42	.67	.95	1.5	2.1	NA	NA	6	9	0	0	1.0	1.4
	June	1.35	.80	1.08	1.5	2.0	NA	NA	8	11	11	15	.6	.8
Tex: Austin	April[a]	1.92	.68	1.31	1.5	2.8	NA	NA	4	8	0	0	.4	.8
	May[a]	1.85	.80	1.48	1.4	2.7	NA	NA	4	7	0	0	.4	.7
	June	2.02	.94	1.90	1.5	3.0	NA	NA	4	7	0	0	.3	.6
Wash: Seattle	April[a]	2.03	.54	1.09	1.5	3.0	0	0	4	8	0	0	.6	1.2
	May[a]	1.88	.50	.93	1.6	3.2	0	0	4	7	17	34	.4	.8
	June	1.93	.52	1.00	1.5	2.8	0	0	6	11	0	0	.5	1.0
Institutional average	April	1.88	0.64	1.19	1.5	2.9	0	0	7	14	8	14	0.6	1.2
	May	1.86	0.61	1.11	1.6	2.8	0	0	7	13	9	14	0.6	1.0
	June	1.78	0.57	0.99	1.5	2.6	0	0	7	12	17	29	0.5	0.9

[a] Since food samples were collected from two or more children who were not between the ages of 9 to 12, data for this month were not used in institutional average.

NA, no analysis.

NS, no sample.

of diet, are corrected for radioactive decay to the midpoint of the sample collection period, where applicable. Dietary intakes, in g/day or pCi/day were obtained by multiplying the food consumption rate in kg/day by the appropriate concentration values. The average food consumption rate during this period was 1.96 kg/day compared to the network average of 1.87 kg/day observed from 1961 through 1968.

Strontium-90 dietary intake during this period averaged 13 pCi/day. This result falls within Range I as defined by the Federal Radiation Council (4). Cesium-137 intakes averaged 22 pCi/day during this period. Strontium-89, iodine-131, and barium-140 concentrations were generally below detectable levels.

All concentrations that are less than or equal to the appropriate minimum detectable level will be reported as zero. The minimum detectable concentration is defined as the measured concentration equal to the 2-standard deviation analytical error. Accordingly, the minimum detectable limits are as follows:

Strontium-89	5 pCi/kg
Strontium-90	2 pCi/kg
Iodine-131	10 pCi/kg
Cesium-137	10 pCi/kg
Barium-140	10 pCi/kg
Radium-226	0.1 pCi/kg

Data from eight auxiliary stations are included in a separate table for general information. This is presented in table 2. These stations do not meet the criterion that the majority of the samples are collected from children who range in age from 9 to 12 years. In order to supplement the existing environmental monitoring networks of the Bureau of Radiological Health, these eight institutions are being sampled in the same manner as the basic stations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1968	April 1969
October–December 1968	July 1969
January–March 1969 and Annual Summary 1968	October 1969

REFERENCES

(1) ANDERSON, E. C., D. J. NELSON, JR. Surveillance for radiological contamination in foods. Amer J Public Health 52:1391–1400 (September 1962).

(2) PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1965. Radiol Health Data 6:548–554 (October 1965).

(3) PUBLIC HEALTH SERVICE, NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Radionuclides in institutional total diet samples, January–March 1968. Radiol Health Data Rep 9:557–560 (October 1968).

(4) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Table 2. Concentration and intake of stable elements and radionuclides in institutional total diets of individuals (auxiliary stations), April–June 1969

Location of institution	Month (1969)	Total weight (kg/day)	Calcium		Potassium		^{89}Sr		^{90}Sr		^{137}Cs		^{226}Ra	
			(g/kg)	(g/day)	(g/kg)	(g/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)	(pCi/kg)	(pCi/day)
Alaska: Juneau	April	1.18	0.62	0.73	1.3	1.5		0	5	6	11	13	0.4	0.5
	May	1.44	.84	1.21	1.7	2.5		0	7	10	0	0	.6	.9
	June	1.25	.46	.58	1.4	1.8	0	0	7	9	45	56	.6	.6
Calif: San Francisco	April	2.29	.58	1.33	1.2	2.7	0	0	3	6	15	34	.4	.9
	May	2.23	.47	1.05	1.3	2.8	0	0	6	12	0	0	.6	1.3
	June	2.17	.48	1.04	1.5	3.3	0	0	4	10	0	0	.3	.7
Miss: Columbia	April	2.04	1.10	2.24	1.5	3.1	NA	NA	10	20	14	29	.6	1.3
	May	2.17	1.07	2.32	1.7	3.8	NA	NA	13	28	19	41	.6	1.3
	June	2.24	.85	1.90	1.7	3.8	NA	NA	12	28	16	36	.6	1.3
Nebr: Omaha	April	2.34	.79	1.85	1.7	4.0	NA	NA	5	12	0	0	.9	2.1
	May	2.30	1.00	2.30	1.7	4.1	NA	NA	7	17	12	29	.8	1.9
	June	2.34	.80	1.87	1.8	4.2	NA	NA	7	16	0	0	.6	1.4
Nev: Carson City	April	1.89	.74	1.40	1.0	1.9	0	0	0	0	0	0	.4	.8
	May	1.62	.58	.94	1.2	1.9	0	0	4	6	0	0	.5	.8
	June	1.41	.37	.52	1.3	1.8	0	0	3	4	0	0	.3	.4
N.Mex: Albuquerque	April	2.83	.86	2.43	1.5	4.4	NA	NA	3	7	0	0	.5	1.4
	May	2.60	.68	1.77	1.4	3.5	NA	NA	2	5	0	0	.3	.8
	June	2.35	.90	2.12	1.6	3.7	NA	NA	4	9	11	26	.4	.9
Ore: Portland	April	1.45	.49	.71	1.7	2.4	0	0	4	6	0	0	.4	.6
	May	2.28	.50	1.14	1.8	4.1	0	0	6	13	0	0	.6	1.4
	June	1.81	.54	.98	1.9	3.4	0	0	5	9	0	0	.5	.9
Utah: Salt Lake City	April	1.97	.52	1.02	1.2	2.3	0	0	4	8	0	0	.5	1.0
	May	2.40	.50	1.20	1.1	2.5	0	0	3	7	0	0	.3	.7
	June	2.41	.55	1.33	1.3	3.1	0	0	0	0	0	0	.4	1.0
Institutional average	April	2.00	0.71	1.46	1.4	2.8	0	0	4	8	5	9	0.5	1.1
	May	2.14	0.71	1.50	1.5	3.1	0	0	6	12	4	9	0.5	1.1
	June	2.00	0.62	1.29	1.6	3.1	0	0	5	10	9	15	0.5	0.9

NA, no analysis.

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Colorado River Basin	1967	December 1968
Florida	1967	February 1969
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, HASL	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U. S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies, Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

26

Radioactivity in Minnesota Municipal Water Supplies[1] January-June 1969

Division of Environmental Sanitation
Minnesota Department of Health

The analysis of various Minnesota waters for radioactivity was initiated in 1956 as part of the Minnesota Water Pollution Control Program. This program was expanded in 1958 to include most of the municipal surface water supplies in the State, as well as selected lakes throughout the State.

As many as 25 surface streams and lakes involving 74 stations have been sampled. At present, nine surface streams and lakes used as municipal water supplies are sampled routinely (figure 1). "Grab" samples of raw and treated water are collected weekly at Hallock, East Grand Forks, Eveleth, Fairmont, and St. Paul and monthly at Crookston, International Falls and St. Cloud. Minneapolis tap water is analyzed weekly. No raw water is collected from the Minneapolis supply.

The samples are forwarded to the Division's laboratory, where they are analyzed for gross alpha and beta radioactivity. A 500-ml sample of water is evaporated into a 2-inch aluminum milk bottle lid planchet and counted in an internal-proportional gas flow counter. Counter standardization is accomplished by adding known

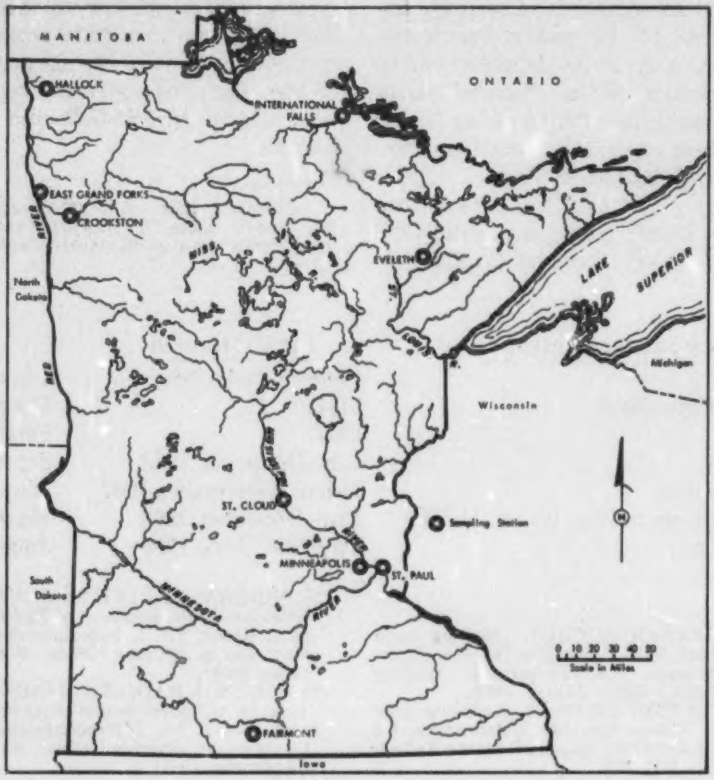
MANITOBA
ONTARIO
HALLOCK
INTERNATIONAL FALLS
EAST GRAND FORKS
CROOKSTON
RED RIVER
North Dakota
MISS.
EVELETH
LAKE SUPERIOR
Michigan
Wisconsin
ST. CLOUD
Sampling Station
N
MINNEAPOLIS
ST. PAUL
South Dakota
MINNESOTA RIVER
0 10 20 30 40 50
Scale in Miles
FAIRMONT
Iowa

Figure 1. Minnesota surface water sampling locations

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[1] Data and information from "Survey of Environmental Radioactivity, January-June 1969." State of Minnesota Department of Public Health, University Campus, Minneapolis, Minn. 55440, Publication No. COO-651-81.

Table 1. Average gross beta radioactivity in Minnesota raw and treated water supplies, January-June 1969

Town and water source	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	25	24	16	20	16	25
	Treated	23	12	20	18	14	12
East Grand Forks, Red Lake River	Raw	19 (5)	• 15 (4)	15 (4)	16 (5)	22 (4)	16 (5)
	Treated	10 (5)	10 (4)	12 (4)	12 (5)	12 (4)	6 (5)
Eveleth, St. Mary's Lake	Raw	12 (5)	11 (3)	11 (4)	12 (4)	13 (4)	10 (4)
	Treated	15 (5)	9 (3)	14 (4)	12 (4)	18 (4)	12 (4)
Fairmont, Budd Lake	Raw	14 (5)	11 (4)	12 (2)	10 (5)	11 (5)	11 (4)
	Treated	7 (5)	5 (4)	5 (2)	6 (5)	9 (5)	6 (4)
Hallock, Two Rivers South Fork	Raw	20 (5)	17 (4)	16 (4)	15 (5)	22 (4)	21 (4)
	Treated	10 (5)	7 (4)	7 (4)	12 (5)	12 (4)	11 (4)
International Falls, Rainy River	Raw	11	7	9	6	9	9
	Treated	6	6	8	3	7	7
Minneapolis tap water	Raw						
	Treated	6 (4)	5 (3)	5 (5)	6 (4)	7 (3)	5 (5)
St. Cloud, Mississippi River	Raw	10	10	10	6	13	15
	Treated	4	8	6	5	8	21
St. Paul, Vadnais Chain of Lakes	Raw	12 (5)	11 (4)	14 (4)	11 (5)	12 (4)	15 (4)
	Treated	7 (5)	8 (4)	8 (4)	10 (5)	8 (4)	5 (4)

Average concentrations (pCi/liter)

• Number in parenthesis gives number of samples averaged.
NS, no sample.

Table 2. Average gross alpha radioactivity in Minnesota raw and treated water supplies, January-June 1969

Town and water source	Type of water	Jan	Feb	Mar	Apr	May	June
Crookston, Red Lake River	Raw	<1	<1	<1	<1	2	4
	Treated	<1	<1	<1	<1	<1	<1
East Grand Forks, Red Lake River	Raw	1 (5)	<1 (4)	<1 (4)	2 (5)	2 (4)	2 (5)
	Treated	<1 (5)	<1 (4)	<1 (4)	<1 (5)	<1 (4)	<1 (5)
Eveleth, St. Mary's Lake	Raw	<1 (5)	<1 (3)	<1 (4)	<1 (5)	<1 (4)	<1 (4)
	Treated	<1 (5)	<1 (3)	<1 (4)	<1 (5)	<1 (4)	<1 (4)
Fairmont, Budd Lake	Raw	3 (5)	5 (4)	5 (2)	5 (5)	5 (5)	5 (4)
	Treated	<1 (5)	1 (4)	<1 (2)	1 (5)	<1 (5)	<1 (4)
Hallock, Two Rivers South Fork	Raw	1 (5)	1 (4)	4 (4)	1 (5)	1 (4)	2 (4)
	Treated	<1 (5)	<1 (4)	<1 (4)	1 (5)	<1 (4)	<1 (4)
International Falls, Rainy River	Raw	1	<1	<1	<1	<1	1
	Treated	<1	<1	<1	<1	<1	<1
Minneapolis tap water	Raw						
	Treated	<1 (4)	<1 (3)	<1 (5)	<1 (4)	<1 (3)	<1 (5)
St. Cloud, Mississippi River	Raw	<1	<1	<1	<1	<2	<1
	Treated	<1	<1	<1	<1	<1	<1
St. Paul, Vadnais Chain of Lakes	Raw	<1 (5)	2 (4)	<1 (4)	<1 (5)	<1 (4)	2 (4)
	Treated	<1 (5)	<1 (4)	<1 (4)	<1 (5)	<1 (4)	<1 (4)

Average concentrations (pCi/liter)

• Number in parenthesis gives number of samples averaged.

amounts of thallium-204 standard to solutions containing the normal range of solids.

Table 1 shows a summary of the monthly average gross beta radioactivity in Minnesota municipal water supplies from January–June 1969. Table 2 shows the gross alpha radioactivity in the same samples for the same period of time. Alpha concentrations reported as <1 pCi/liter were considered as 0.5 pCi/liter for averaging purposes.

The data obtained on gross beta radioactivity in Minnesota surface waters show a variation of concentrations, with no readily apparent trends. Variations in precipitation and flow rates of streams could contribute to this fluctuation Monthly averages of gross beta radioactivity in Minnesota raw surface waters ranged from 3 to 25 pCi/liter, which is well below the Public Health Service Drinking Water Standards (*1*).

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962. Public Health Service Publication No. 956, Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1968	November 1969

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, HASL	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation	April–June 1968	October 1969

29

1. Radiation Alert Network September 1969

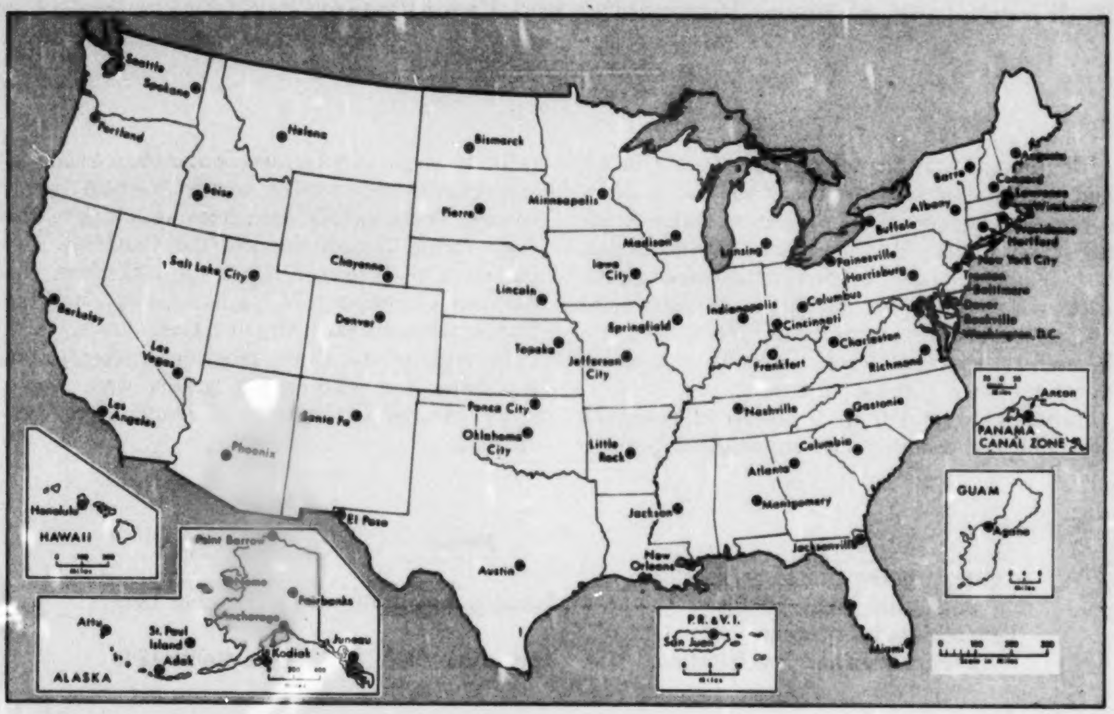
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique, during September 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.


Seattle
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Boise
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Minneapolis
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Berkeley
Denver
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Topeka
Jefferson City
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
Little Rock
El Paso
Austin
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
Madison
Lansing
Iowa City
Springfield
Indianapolis
Cincinnati
Columbus
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Charleston
Frankfort
Richmond
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
P.R. & V.I.
San Juan
PANAMA CANAL ZONE
Ancon
GUAM
Agana
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, September 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
		Air	Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	19	9	0	3	Dec 69	2	153	2	153	87
Alaska:	Adak	2	1	1	1	Dec 69	(c)				
	Anchorage	1	0	0	0	Aug 69	(c)				
	Attu Island	20	1	0	0	Jan 70	1	7	(e)		
	Fairbanks	17	4	0	2	Sept 69	2	7	2	7	0
	Juneau	20	2	0	1	Oct 69	6	138	6	138	0
	Kodiak	18	0	0	0	Nov 69	(c)				
	Nome	(b)				May 69	(c)				
	Pt. Barrow	30	0	0	0	Apr 69	(c)				
	St. Paul Island	30	1	0	1	June 69	(c)				
Ariz:	Phoenix	19	12	1	5	Oct 69	(c)				
Ark:	Little Rock	8	3	0	2	Aug 69	(c)				
Calif:	Berkeley	20	1	0	0	Nov 69	(c)				
	Los Angeles	19	3	0	1	May 69	(c)				
C.Z:	Ancon	15	1	0	0	Nov 69	(c)				
Colo:	Denver	21	6	1	4	Nov 69	2	19	(d)		
Conn:	Hartford	21	2	0	1	Sept 69	7	102	7	102	2
Del:	Dover	21	4	0	1	July 69	(c)				
D.C:	Washington	22	2	0	1	Apr 69	4	34	4	34	0
Fla:	Jacksonville	24	1	0	0	Aug 69	10	220	6	130	32
	Miami	19	0	0	0	Sept 69	8	129	7	126	0
Ga:	Atlanta	21	2	1	1	June 69	3	61	3	61	45
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	25	1	0	0	Jan 70	(c)				
Idaho:	Boise	21	6	1	2	Jan 70	2	17	2	17	7
Ill:	Springfield	18	4	0	1	Apr 69	(c)				
Ind:	Indianapolis	(b)				June 69	(c)				
Iowa:	Iowa City	18	3	0	1	Nov 69	4	20	4	20	0
Kans:	Topeka	20	5	1	3	Aug 69	7	61	7	61	1
Ky:	Frankfort	(b)				Apr 69	(c)				
La:	New Orleans	18	1	0	0	Apr 69	6	81	(d)		
Maine:	Augusta	21	3	0	1	Oct 69	6	140	6	140	0
Md:	Baltimore	20	3	0	1	Sept 69	6	47	6	47	11
	Rockville	11	1	0	1	Jan 70	(c)				
Mass:	Lawrence	20	4	0	1	Nov 69	6	107	6	107	17
	Winchester	21	4	0	1	Dec 69	5	139	5	139	0
Mich:	Lansing	20	4	0	1	Jan 70	5	32	5	32	3
Minn:	Minneapolis	21	3	0	1	July 69	3	677	3	677	72
Miss:	Jackson	18	2	0	2	Oct 69	2	46	2	46	23
Mo:	Jefferson City	20	4	0	2	June 69	7	159	7	139	0
Mont:	Helena	21	3	1	2	Dec 69	2	21	2	21	0
Nebr:	Lincoln	15	7	2	5	June 69	4	46	3	40	5
Nev:	Las Vegas	10	2	0	1	Sept 69	(c)				
N.H:	Concord	19	2	0	1	Apr 69	(c)				
N.J:	Trenton	20	3	0	1	Oct 69	6	191	6	191	3
N.Mex:	Santa Fe	(b)				Dec 69	(c)				
N.Y:	Albany	10	2	0	1	June 69	7	234	7	234	80
	Buffalo	21	3	0	1	Nov 69	(c)				
	New York City	20	2	0	1	Dec 69	(c)				
N.C:	Gastonia	16	0	0	5	Nov 69	6	74	(d)		
N.Dak:	Bismarck	19	4	1	2	Apr 69	2	10	2	10	0
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	10	4	0	2	Oct 69	2	42	(e)		
	Painesville	21	4	1	2	Sept 69	8	99	8	99	7
Okla:	Oklahoma City	12	4	0	1	Jan 70	5	72	5	72	8
	Ponca City	21	7	0	1	Sept 69	6	115	6	115	0
Ore:	Portland	19	3	0	1	June 69	9	108	8	108	10
Pa:	Harrisburg	16	3	0	1	June 69	(c)				
P.R:	San Juan	(b)				Oct 69	(c)				
R.I:	Providence	16	5	0	2	Jan 70	3	70	3	70	10
S.C:	Columbia	20	3	0	2	Dec 69	7	100	6	90	6
S.Dak:	Pierre	12	8	2	6	Oct 69	(c)				
Tenn:	Nashville	21	4	0	1	Jan 70	4	40	4	40	1
Tex:	Austin	9	10	1	5	July 69	2	59	(d)		
	El Paso	(b)				Apr 69	(c)				
Utah:	Salt Lake City	27	3	1	2	May 69	1	3	1	3	0
Vt:	Barre	20	4	0	3	Aug 69	6	55	6	55	7
Va:	Richmond	20	2	0	1	Aug 69	3	69	3	69	10
Wash:	Seattle	5	0	0	0	Aug 69	11	108	(d)		
	Spokane	1	1	1	1	July 69	(c)				
W.Va:	Charleston	20	2	0	1	Dec 69	6	84	6	84	12
Wis:	Madison	21	2	0	1	Aug 69	7	31	7	31	4
Wyo:	Cheyenne	21	8	1	4	Sept 69	2	16	2	16	5
Network summary		1,159	12	0	2		6	111	5	96	13

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

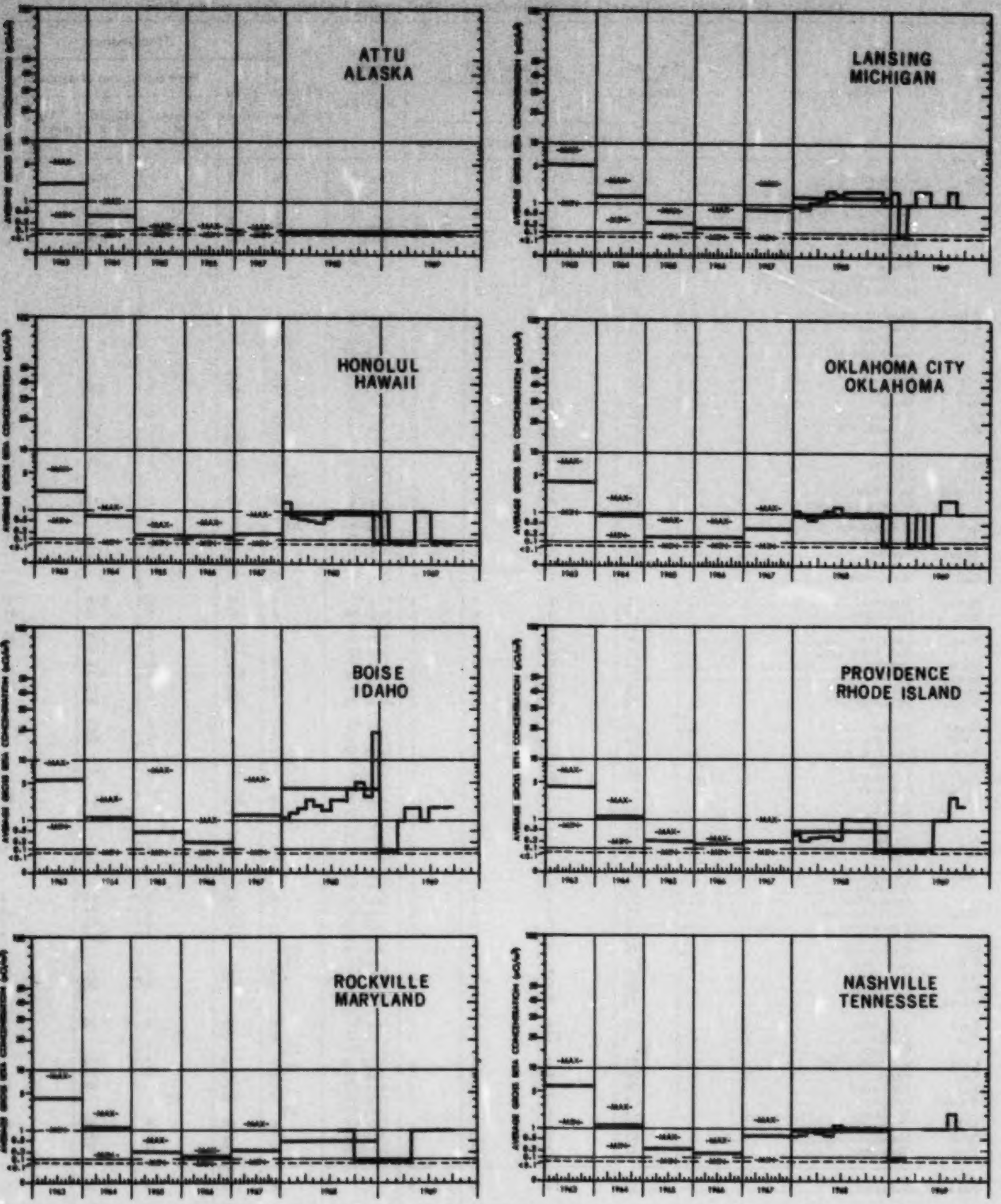

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–September 1969

2. Canadian Air and Precipitation Monitoring Program,[1] September 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for September 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, September 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	28	0.3	0.0	0.1	NS	NS
Coral Harbour	24	.2	.0	.1		
Edmonton	30.	.2	.0	.1		
Ft. Churchill	19	.2	.1	.1		
Ft. William	22	.2	.0	.1		
Fredericton	30	.3	.0	.1		
Goose Bay	30	.2	.0	.1		
Halifax	27	.3	.0	.1		
Inuvik	30	.2	.0	.1		
Montreal	30	.5	.0	.2		
Moosonee	29	.3	.0	.1		
Ottawa	30	.3	.0	.2		
Quebec	30	.2	.0	.1		
Regina	30	.3	.0	.1		
Resolute	30	.2	.0	.1		
St. John's, Nfld	30	.3	.0	.1		
Saskatoon	29	.2	.0	.1		
Saulte Ste Marie	29	.4	.0	.1		
Toronto	30	.4	.0	.2		
Vancouver	30	.2	.0	.1		
Whitehorse	30	.2	.0	.1		
Windsor	30	.3	.0	.1		
Winnipeg	30	.3	.0	.1		
Yellowknife	30	.1	.0	.1		
Network summary	687	0.5	0.0	0.1		

NS, no sample.

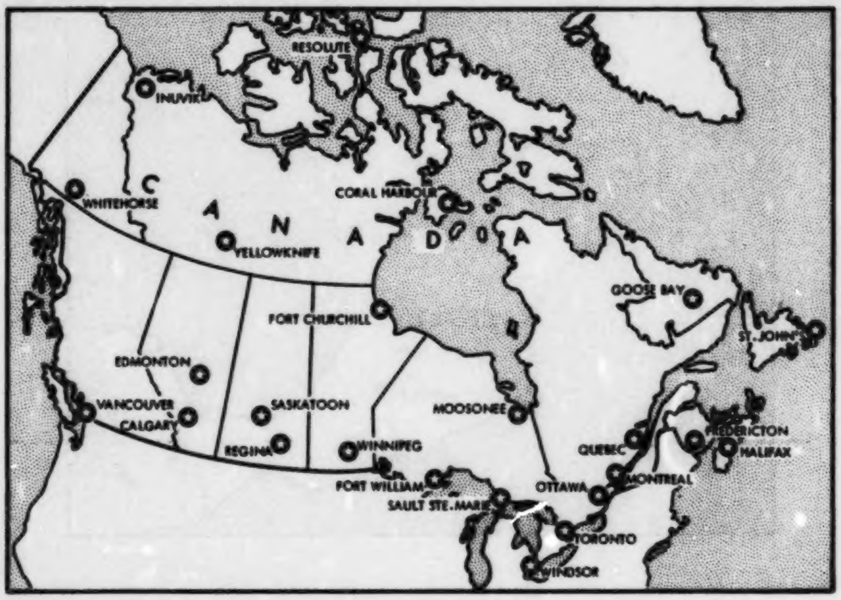
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
MOOSONEE
FREDERICTON
HALIFAX
QUEBEC
REGINA
WINNIPEG
MONTREAL
FORT WILLIAM
OTTAWA
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipatation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

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3. Mexican Air Monitoring Program March and April 1969

National Commission of Nuclear Energy

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Previsión del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6 by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during March and April 1969 are presented in tables 3 and 4.

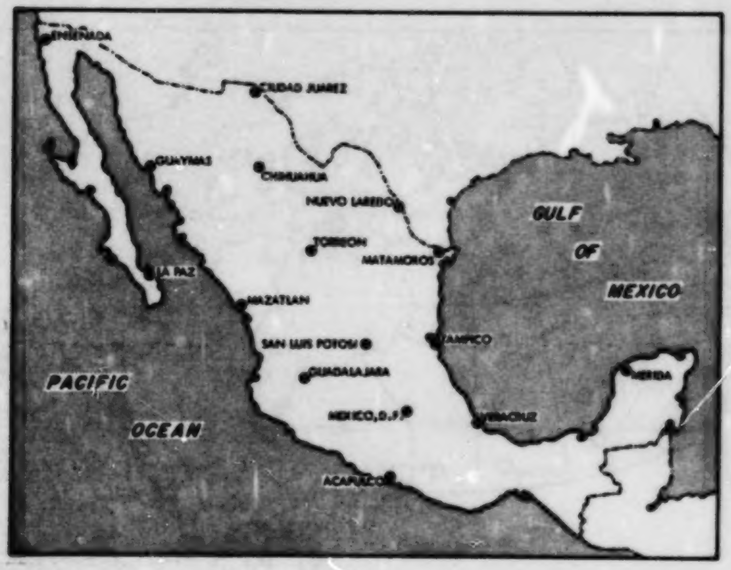

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, March 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	24	0.3	0.1	0.2
Chihuahua	12	.4	.2	.3
Ensenada	NS			
La Paz	1	.1	.1	.1
Matamoros	NS			
Mazatlán	13	.6	.2	.3
Mérida	11	.3	.1	.2
México, D.F.	3	.4	.1	.2
Nuevo Laredo	NS			
Tampico	NS			
Torreón	NS			
Veracruz	NS			

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, April 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	16	0.7	0.1	0.4
Chihuahua	9	.5	.1	.4
Ensenada	NS			
La Paz	NS			
Matamoros	NS			
Mazatlán	17	.6	.5	.5
Mérida	4	.2	.2	.2
México, D. F.	2	.5	.3	.4
Nuevo Laredo	NS			
Tampico	NS			
Torreón	1	.5		
Veracruz	NS			

NS, no sample, station temporarily shutdown.

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4. Pan American Air Sampling Program September 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The September 1969 air monitoring results from the participating countries are given in table 5.

Table 5. Summary of gross beta radioactivity in Pan American surface air, September 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	18	0.25	0.01	0.11
Bolivia:	La Paz	13	.14	.03	.08
Chile:	Santiago	27	.34	.03	.14
Colombia:	Bogota	19	.02	.00	.01
Ecuador:	Cuenca	NS			
	Guayaquil	10	.09	.01	.04
	Quito	16	.01	.00	.01
Guyana:	Georgetown	4	.09	.04	.06
Jamaica:	Kingston	21	.06	.01	.04
Peru:	Lima	NS			
Venezuela:	Caracas	21	.06	.01	.04
West Indies:	Trinidad	21	.09	.01	.04
Pan American summary		170	0.34	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.
NS, no sample, station temporarily shut down.

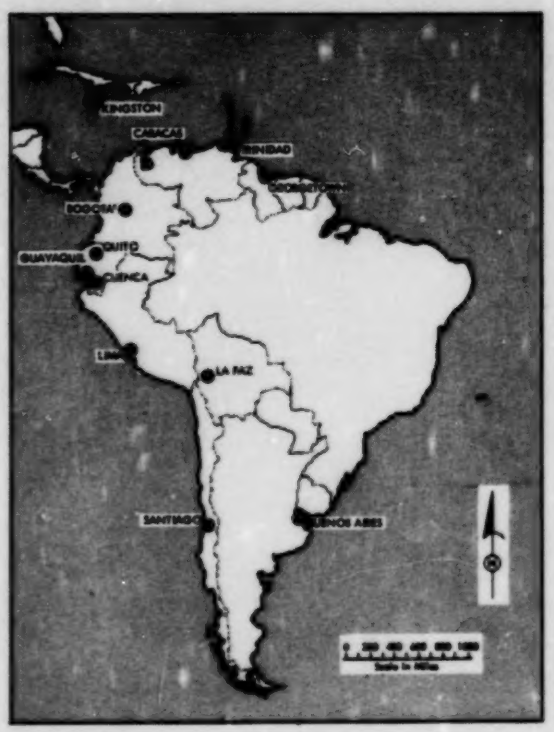

Figure 5. Pan American Air Sampling Program stations

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REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Mexicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiológica (1966).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Bettis Atomic Power Laboratory, the Neutron Devices Laboratory and the Oak Ridge National Laboratory.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Bettis Atomic Power Laboratory[2] January–December 1968

Westinghouse Electric Corporation
Pittsburgh, Pa.

The Bettis Atomic Power Laboratory (BAPL), operated for the Atomic Energy Commission by the Westinghouse Electric Corporation, was established in 1949 to conduct research and development operations related to naval atomic propulsion systems and to the central station power reactor at Shippingport, Pa. Routine environmental monitoring data from the sampling locations shown in figure 1 show no significant contribution from laboratory operations to environmental radioactivity levels.

Gaseous radioactive waste

The release of gaseous radioactive waste is monitored by continuous air sampling to assure compliance with laboratory regulations. The stack gas limits for the laboratory are based on the 168-hour nonoccupational maximum permissible concentrations in air as specified in AEC Manual Chapter 0524. At no time during 1968 did the concentration of stack releases exceed the required limits. The general public outside the boundary of the laboratory was not exposed to radiation above normal background levels as a result of laboratory operations.

Total gaseous radioactivity released to the environment during 1968 was 1.64 mCi alpha and less than 164 mCi beta-gamma. Due to an increased volume of air discharged, the total radioactivity was greater than last years's quantities; the average concentration of radioactivity, however, remained the same.

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[2] Summarized from "Bettis Atomic Power Laboratory, Environmental Monitoring Report, Calendar Year 1968" (WAPD-O-(IHR)-2024).

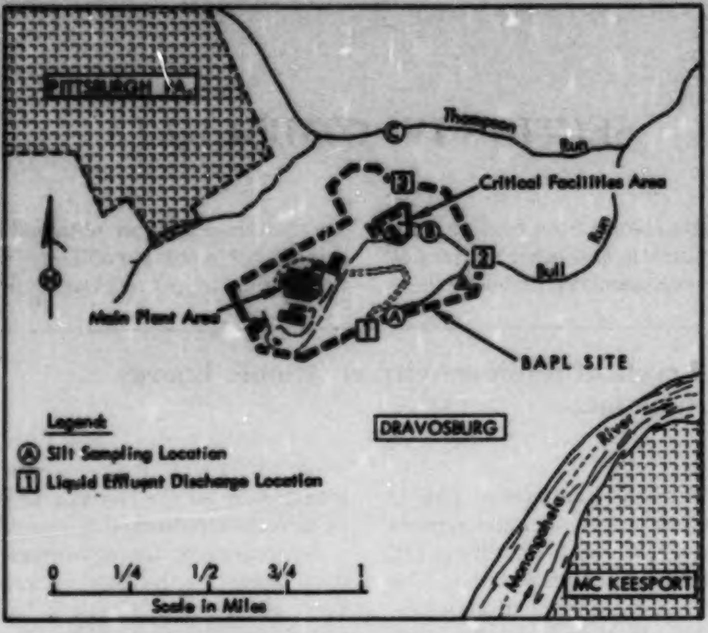
PITTSBURGH PA.
Thompson Run
Critical Facilities Area
Bull Run
Main Plant Area
BAPL SITE
Legend:
Ⓐ Silt Sampling Location
1 Liquid Effluent Discharge Location
DRAVOSBURG
Monongahela River
MC KEESPORT
0
1/4
1/2
3/4
1
Scale in Miles

Figure 1. Bettis Atomic Power Laboratory sampling stations

Liquid radioactive waste

Liquid effluent discharged from the laboratory is sampled continuously. Composite samples are analyzed weekly for gross alpha and gross beta-gamma radioactivity, and quarterly for strontium-90 radioactivity.

The average concentrations of gross beta radioactivity in the main laboratory liquid effluent during 1968 was 120 pCi/liter. This was lower than the average concentration of 520 pCi/liter observed for the year 1967.

Average radioactivity in liquid waste effluent from the critical facility operations during 1968 were: alpha radioactivity—610 pCi/liter, beta-gamma radioactivity—1.00 nCi/liter. Comparable values for 1967 were <400 pCi/liter for alpha radioactivity and 1.36 nCi/liter for beta-gamma radioactivity.

Background monitoring stations

Beta-gamma radiation levels were continuously monitored and recorded at 34 film badge monitoring stations located at 100-yard intervals along the boundary of the laboratory property which lies within the controlled confines of the Bettis Atomic Power Laboratory site.

The average beta-gamma radiation level during 1968 was 0.055 mR/h for the main laboratory area and 0.014 mR/h for the critical facility area. The respective average exposure values for 1967 were 0.072 mR/h and 0.009 mR/h. Table 1 summarizes results obtained during 1968 from the background monitoring stations.

Table 1. Beta-gamma background radiation monitoring, Bettis, 1968

Location	Exposure levels (mR/h)	
Main laboratory area (20 locations)	Maximum	0.383
	Average	.055
Critical facility area (14 locations)	Maximum	.016
	Average	.014
All locations	Average	.038

Stream silt

Stream silt samples were collected quarterly at the three locations shown in figure 1. The results of analysis of these samples are presented in table 2. The average alpha and beta-gamma radio-

Table 2. Radioactivity in stream silt, Bettis, 1968

Period 1968	Number of samples	Radioactivity (pCi/g)			
		Alpha		Beta-gamma	
		Range	Average	Range	Average
January–March	3	0.4– 9.4	4.6	0.6– 79.3	46.9
April–June	6	1.0–12.4	6.6	3.0– 92.6	42.5
July–September	9	4.7–12.1	9.2	6.7– 96.1	41.5
October–December	3	11.5–33.3	18.8	13.8–180.2	75.3

Table 3. Strontium-89 and strontium-90 in stream silt Bettis, 1968

Period 1968	Concentration (pCi/g of silt)	
	Strontium-89	Strontium-90
January–March	<0.3	1.04
April–June	< .3	.41
July–September	< .1	.16
October–December	< .3	.38

activity concentrations of stream silt samples for 1968 were 9.8 pCi/g and 51.5 pCi/g, respectively. Although these concentrations represent an increase over those for 1967, they are consistent with concentrations detected in previous years.

Semiannual analyses for strontium-89 and strontium-90 were obtained for composites of quarterly silt samples. Table 3 presents the results of these analyses for samples collected during 1968.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1966	October 1967
January–December 1967	March 1969

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2. Neutron Devices Department[1] July–December 1968

General Electric Company
St. Petersburg, Florida

The Neutron Devices Department, shown in figure 2 is an electronic component production facility. The plant maintains an environmental monitoring program to measure the levels of radioactive environmental contamination associated with plant effluents. These measurements serve as an index of the effectiveness of the plants's contamination control measures. Effluent radioactivity concentrations and associated atmospheric and stream dilution factors indicate offsite radioactivity concentrations encountered by the general population are substantially lower than the guides for continuous nonoccupational exposure established by AEC and documented in the "AEC Manual."

Sewer effluent monitoring

A combined sewer effluent sample is obtained daily near the perimeter of the plant's property. During the sampling period, 7 of 362 samples analyzed showed detectable concentrations of tritium (>90 nCi/liter). The maximum concentration (370 nCi/liter), detected on November 12, 1968 represented 12 percent of the continuous nonoccupational exposure guide. Calculations based on radioactivity releases from the process waste system, and the plant's water discharges, indicate that the average tritium concentration in the combined sewer effluent for July–December of 1968 was less than 3.5 percent of the AEC radiation protection standard for continuous nonoccupational exposure.

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[1] Summarized from "Environmental Monitoring, July 1 through December 31, 1968" General Electric Company, Neutron Devices Department, St. Petersburg, Fla.

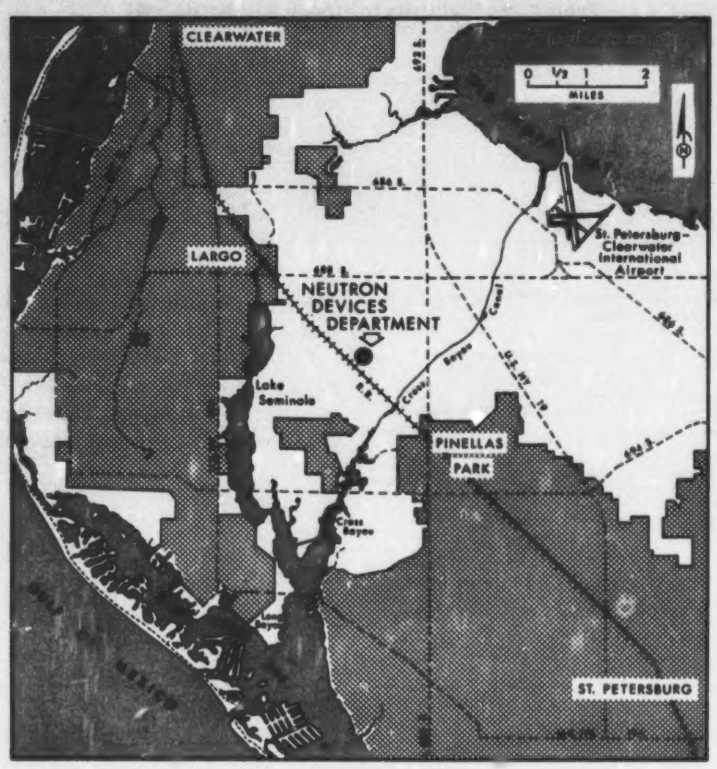
CLEARWATER
0 1/2 1 2
MILES
LARGO
NEUTRON DEVICES DEPARTMENT
St. Petersburg-Clearwater International Airport
Lake Seminole
Cross Bayou Canal
U.S. HY 19
PINELLAS PARK
Cross Bayou
Long Bayou
GULF OF MEXICO
ST. PETERSBURG

Figure 2. Location of the Neutron Devices Department

Surface water sampling

Surface water samples are collected at monthly intervals at selected locations within 8 miles of the plant. The sampling areas are determined by interrelating the concentrations of radioactivity in exhaust stack effluent with meteorological data. There were no indications of tritium (>90 nCi/liter) in the 43 surface water samples analyzed during the sampling period.

Milk sampling results

Analyses of eight raw milk samples, collected from one local dairy farm by the Pinellas County Health Department, revealed no detectable concentrations (>90 nCi/liter) of tritium.

Air sampling results

No detectable amounts of tritium gas (>20 nCi/m^3) or tritium oxide (>5.0 nCi/m^3) were found in two samples of air obtained downwind from the exhaust stack at the perimeter of the plant property.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	May 1969
January–June 1968	December 1969

3. Oak Ridge Area[4]
July–December 1968

Union Carbide Nuclear Company
Oak Ridge, Tenn.

Oak Ridge area is a complex made up primarily of the Y-12 Plant, the Oak Ridge National Laboratory (ORNL), and the Oak Ridge Gaseous Diffusion Plant (ORGDP).

Radioactive waste materials arising from the operation of atomic energy installations in the Oak Ridge area are collected, treated, and disposed of according to their physical states. Solid wastes are buried in a Conasauga shale formation which has a marked ability to fix radioactive materials by an ion exchange mechanism. Liquid wastes which contain long-lived fission products are confined in storage tanks or are concentrated by evaporation and disposed of in deep wells. Low-level liquid wastes are discharged, after preliminary treatment, to the surface streams. Air that may become contaminated by radioactive materials is exhausted to the atmosphere from several tall stacks after treatment by means of filters, scrubbers, and/or precipitators.

Air monitoring

Atmospheric contamination by radioactive materials occurring in the general environment of East Tennessee is monitored by two systems of monitoring stations. One system consists of nine stations which encircle the plant areas (figure 3) and provide data for evaluating the impact of all Oak Ridge operations on the immediate environment. A second system consists of eight stations encircling the Oak Ridge area at distances of from 12 to 75 miles (figure 4). This system provides data to aid in evaluating local conditions and to assist in determining the spread or dispersal of contamination should a major incident occur.

Sampling for radioactive particulates is carried out by passing air continuously through a filter paper. Average radioactivity concentrations are presented in tables 4 and 5. Airborne radioactive iodine is monitored in the immediate environment of the plant areas by passing air through a cartridge containing activated charcoal.

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[4] Summarized from "Environmental Levels of Radioactivity for the Oak Ridge area, Report Period, July–December 1968. Health Physics and Safety Section, Health Physics Division, Oak Ridge National Laboratory.

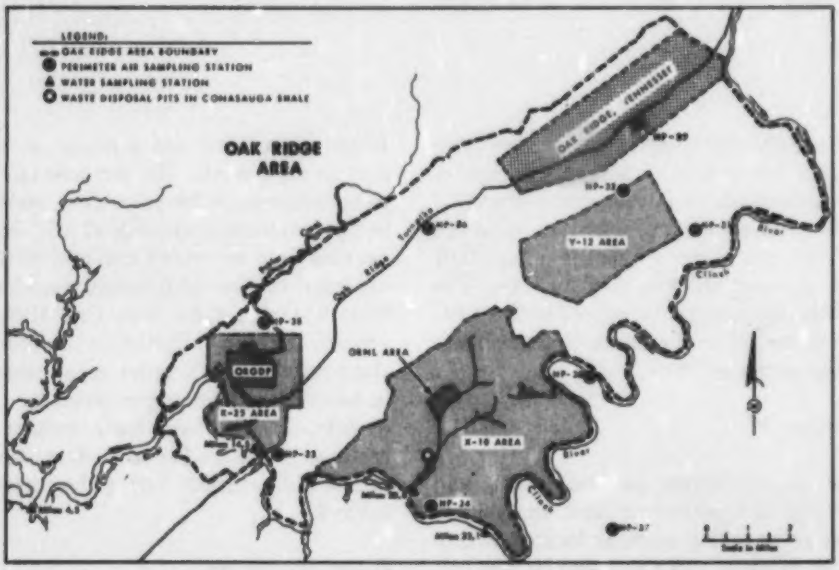
LEGEND:
OAK RIDGE AREA BOUNDARY
PERIMETER AIR SAMPLING STATION
WATER SAMPLING STATION
WASTE DISPOSAL PITS IN CONASAUGA SHALE
OAK RIDGE AREA
OAK RIDGE, TENNESSEE
Y-12 AREA
ORGDP
K-25 AREA
ORNL AREA
X-10 AREA
Oak Ridge Turnpike
Clinch River
Clinch River
HP-24
HP-37
Scale in Miles

Figure 3. Oak Ridge area environmental sampling locations

Table 4. Long-lived gross beta radioactivity of particulates in air, Oak Ridge area, July–December 1968

Perimeter stations				Remote stations			
Station number (figure 3)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]	Station number (figure 4)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]
HP-31	26	0.11	0.11	HP-51	26	0.09	0.10
HP-32	26	.16	.16	HP-52	25	.11	.11
HP-33	26	.09	.09	HP-53	26	.10	.10
HP-34	26	.10	.10	HP-54	25	.08	.08
HP-35	26	.11	.11	HP-55	25	.09	.10
HP-36	[b] 151	.12	.12	HP-56	26	.11	.11
HP-37	26	.07	.07	HP-57	26	.09	.09
HP-38	26	.11	.11	HP-58	21	.11	.11
HP-39	26	.09	.09				
Average		0.10	0.10	Average		0.10	0.10

[a] The applicable AEC Radiation Protection Standard is 100 pCi/m³.
[b] Sampling frequency changed to 5 days per week beginning 9/20/68.

Table 5. Long-lived gross alpha radioactivity of particulates in air, Oak Ridge area, July–December 1968

Perimeter stations				Remote stations			
Station number (figure 3)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]	Station number (figure 4)	Number of samples	Average concentration (pCi/m³)	Percent of AEC standard[a]
HP-31	26	0.002	0.10	HP-51	26	0.001	0.05
HP-32	26	.002	.10	HP-52	25	.002	.10
HP-33	26	.002	.10	HP-53	26	.001	.05
HP-34	26	.001	.05	HP-54	25	.001	.05
HP-35	26	.002	.10	HP-55	25	.001	.05
HP-36	[b] 151	.004	.20	HP-56	26	.001	.05
HP-37	26	.002	.10	HP-57	26	.001	.05
HP-38	26	.001	< .01	HP-58	21	.003	.15
HP-39	26	.002	.10				
Average		0.002	0.10	Average		0.001	0.05

[a] The applicable AEC Radiation Protection Standard for natural uranium in air is 2 pCi/m³.
[b] Sampling frequency changed to 5 days per week beginning 9/20/68.

During the July–December 1968 surveillance period, 234 samples were collected from perimeter monitoring stations and analyzed for iodine-131. Of these, the maximum concentration detected was 0.74 pCi/m³, the minimum was less than 0.01 pCi/m³, and the average was 0.02 pCi/m³. The radiation protection standard specified in the AEC Manual for iodine-131 in the ambient atmosphere in uncontrolled areas is 100 pCi/m³.

Milk monitoring

Raw milk is monitored for iodine-131 and strontium-90 by the collection and analysis of samples from 12 sampling stations located within a radius of 50 miles of ORNL. Samples are collected weekly at each of eight stations located on the fringe of the Oak Ridge area. Four stations, located more remotely with respect to the Oak Ridge operations, are sampled at a rate of one station each week. The purpose of the milk sampling program is twofold: first, samples collected in the immediate vicinity of the Oak Ridge area provide data by which one may evaluate possible exposure to the neighboring population resulting from waste releases from Oak Ridge operations; second, samples collected at the more remote stations provide background data which are essential in establishing the proper index for the evaluation of data obtained from local samples. The concentrations of iodine-131 and strontium-90 detected in raw milk samples during the period are given in table 6.

Water monitoring

Large volume, low-level liquid wastes originating at ORNL are discharged, after some pre-

Table 6. Radionuclides in raw milk, Oak Ridge area July–December 1968

Radionuclide and location	Concentration (pCi/liter)		
	Maximum	Minimum[a]	Average
Iodine-131			
Immediate environs	15	<10	5.1
Remote environs	<10	<10	5.0
Strontium-90			
Immediate environs	28	9.0	19
Remote environs	23	12	17

[a] The minimum detectable concentrations of iodine-131 and strontium-90 in milk are 10 pCi/liter and 2 pCi/liter, respectively. In averaging, one-half of the minimum detectable concentration was used for all samples showing an activity less than this concentration.

liminary treatment, into the Tennessee River system by way of White Oak Creek and the Clinch River. Liquid wastes originating at the ORGDP and Y-12 Plant are discharged to Poplar Creek and thence to the Clinch River. Releases are controlled so that resulting average concentrations in the Clinch River comply with AEC radiation protection standards. The radioactivity concentration from White Oak Creek is measured, and concentration values for the Clinch River are calculated on the basis of the dilution provided by the river.

Water samples are taken at a number of locations in the Clinch River, beginning at a point above the entry of wastes into the river and ending at Center's Ferry near Kingston, Tenn. Stream gauging operations are carried on continuously to obtain dilution factors for calculating the probable concentrations of wastes in the river.

Samples are analyzed for the long-lived beta-particle emitters, uranium, and the transuranic alpha-particle emitters.

Analyses are made of the effluent for the long-lived radionuclides only, since cooling time and hold up time in the waste effluent system are such that short-lived radionuclides are normally not present. The average concentrations of major radionuclides in the Clinch River are given in table 7 for the period from July through December 1968.

Two quarterly composite water samples from the Clinch River were analyzed for uranium during this period. For these samples, the uranium concentrations were less than 1 pCi/liter, the level of detectability. The AEC radiation protection standard for natural uranium in water released to unrestricted areas is 20 nCi/liter.

Table 7. Concentrations of major radionuclides in the Clinch River, July–December 1968

Radionuclide	Average concentration (pCi/liter)		
	Location on Clinch River[a]		
	Mile: 23.1 (Upstream)	Mile: 20.8[b] (Outfall)	Mile: 4.5 (Downstream)
Strontium-90	0.4	0.5	0.9
Cerium-144	.2	<.1	.3
Cesium-137	ND	.1	1.4
Ruthenium-106	.4	.4	.5
Cobalt-60	8.8	<.1	4.4
Zirconium niobium-95	ND	<.1	.1
Gross beta	9.8	3.3	7.6

[a] The location on Clinch River is given in terms of the distance upstream from the Tennessee River. See figure 3.

[b] The concentrations at mile: 20.8 are not measured directly but the values are calculated based on the levels of waste released and the dilution provided by the river.

ND, nondetectable.

Gamma measurements

External gamma radiation levels are measured monthly at a number of locations in the Oak Ridge area. Measurements are taken with a Geiger-Mueller tube at a distance of 3 feet above the ground. The results are shown in table 8.

Table 8. External gamma radiation levels, Oak Ridge area, July–December 1968

Location	Average dose rates[a] (mR/h)
Solway Gate	0.012
Y-12, East Portal	.012
Newcomb Road	.012
Gallaher Gate	.011
White Wing Gate	.011

[a] The background in the Oak Ridge area, determined in 1943, was approximately 0.012 mR/h.

Discussion of data

The average air contamination level for gross beta radioactivity, as shown by the continuous air monitoring filter data, for both the immediate and remote environs of the plants (figures 3 and 4) was 0.10 percent of the AEC radiation protection standard for uncontrolled areas.

The average air contamination levels for gross alpha radioactivity, as shown by the continuous air monitoring filter data, for the immediate and remote environs of the plants were 0.10 percent and 0.05 percent, respectively, of the AEC radiation protection standard for natural uranium for application to uncontrolled areas.

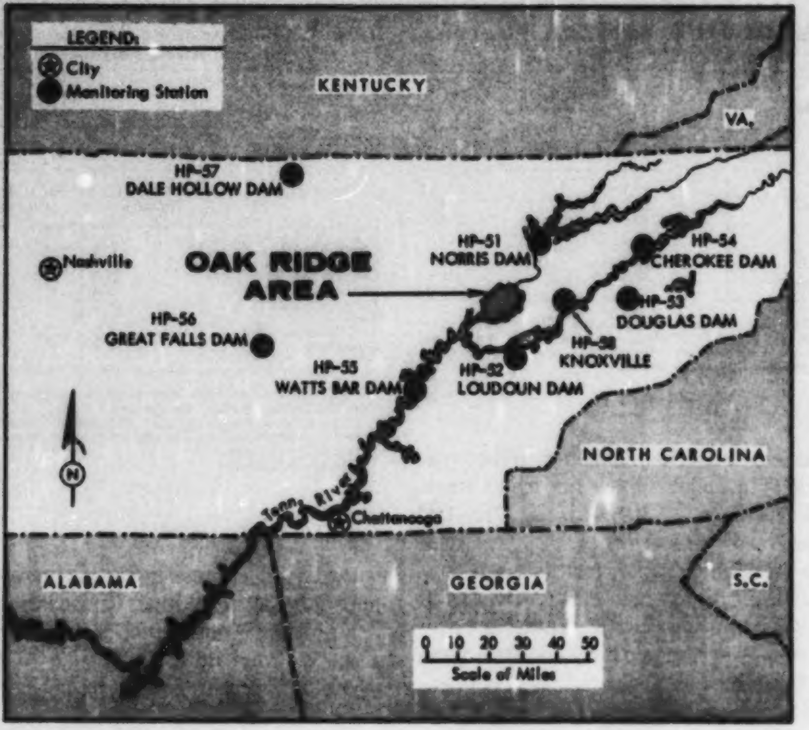
LEGEND:
City
Monitoring Station
KENTUCKY
VA.
HP-57
DALE HOLLOW DAM
Nashville
OAK RIDGE AREA
HP-51
NORRIS DAM
HP-54
CHEROKEE DAM
HP-53
DOUGLAS DAM
HP-56
GREAT FALLS DAM
HP-55
WATTS BAR DAM
HP-52
LOUDOUN DAM
HP-58
KNOXVILLE
N
NORTH CAROLINA
Tenn. River
Chattanooga
ALABAMA
GEORGIA
S.C.
0 10 20 30 40 50
Scale of Miles

Figure 4. Remote air monitoring stations, Oak Ridge area

The average concentration of iodine-131 in air in the immediate environs of the plants was 0.02 pCi/m^3. This is approximately 0.02 percent of the AEC radiation standard for uncontrolled areas.

The average concentrations of iodine-131 in raw milk in the immediate and remote environs of the Oak Ridge area were 5.1 pCi/liter and 5.0 pCi/liter, respectively. These levels fall within the limits of FRC Range I if the average intake per individual is assumed to be 1 liter of milk per day.

The average concentrations of strontium-90 in raw milk in the immediate and remote environs of the controlled area were 19 pCi/liter and 17 pCi/liter, respectively.

These levels fall within the limits of FRC Range I for transient rates of daily intake of strontium-90 for application to the average of suitable samples of an exposed population.

The calculated average concentration of gross beta radioactivity in the Clinch River at mile 20.8 (the point of entry of most of the wastes) and the measured average concentration at mile 4.5 (near Kingston, Tenn.) were 3.3 pCi/liter and 7.6 pCi/liter, respectively. These values are 0.31 percent and 0.34 percent of the weighted average AEC radiation protection standards. The higher than normal average concentration reported for radioactivity at mile 23.1, Melton Hill Dam, was due primarily to cobalt-60. This contamination was found in the river upstream from the ORNL waste outfall and was the result of a source of contamination from a nuclear company upstream from Oak Ridge Operations. The average concentration of transuranic alpha-particle emitters in the Clinch River at mile 20.8 was 0.001 pCi/liter which is less than 0.01 percent of the weighted average AEC radiation protection standard.

The average concentration of natural uranium materials in the Clinch River, reflecting the effects of all Oak Ridge plants, was less than 0.01 percent of the AEC radiation protection standard for natural uranium.

The average external gamma radiation measured in the town of Oak Ridge and at the perimeter of the Oak Ridge area was 0.012 mR/h, which is approximately the same as that level measured during the period prior to Oak Ridge operations.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	October 1968
January–June 1968	June 1969

Reported Nuclear Detonations, October 1969

(includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that a nuclear test of low yield (less than 20 kilotons TNT equivalent) was conducted underground by the Atomic Energy Commission at its Nevada Test Site on December 5, 1969.

On December 6, 1969, the United States recorded seismic signals which originated in the Kazakh Desert, south of the Urals, in the U.S.S.R. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

Two nuclear tests, one of low yield (less than 20 kilotons TNT equivalent) and the other of low-intermediate yield rnge (20–200 kilotons TNT equivalent) were conducted underground on December 17, 1969, by the Atomic Energy Commission at its Nevada Test Site.

Another underground nuclear test of low-intermediate yield was conducted December 18, 1969, by the Atomic Energy Commission at its Nevada Test Site.

The United States recorded seismic signals on December 29, 1969, which originated from the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of a nuclear test in the low-intermediate yield range (20–200 kilotons TNT equivalent).

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

DIAGNOSTIC DENTAL X RAYS AND THE PATIENT—AN OVERVIEW. *Bureau of Radiological Health. Radiological Health Data and Reports, Vol.* 11, *January 1970*, pp. 1–5.

In 1964, approximately one quarter of the civilian non-institutional population in the United States was exposed to dental x rays. The average estimated skin exposure was 1,144 mR per film. The absorbed doses were on the order of 25–80 mrad to organs in or near the direct beam with a genetically significant dose of <0.01 mrad per year. The status of exposure control programs and standards and compliance is discussed and activities for further reducing exposure are identified.

KEYWORDS: Absorbed doses, dental x ray, genetically significant dose, human organs, United States.

EVALUATION OF EMISSIONS FROM RADIUM DIAL WATCHES. *Herbert F. Klein, Earl W. Robinson, Royce L. Gragg, and James W. Rolofson. Radiological Health Data and Reports, Vol.* 11, *January 1970*, pp. 7–9.

Seventeen U.S. Army surplus radium-dial pocket watches were examined for radium content. The absorbed dose rates at the surface of the watches were measured and found to vary from 23.8 to 36.1 mrad/h–μCi. A simulated radium dial watch was constructed and used to estimate absorbed dose rates to various parts of the human body.

KEYWORDS: Absorbed dose rates, human organs, pocket watches, radium.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 2, February 1970

In August 1959, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and X rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

Radiological Health Data and Reports, a monthly publication of the Public Health Service, includes data and reports provided to the Bureau of Radiological Health by Federal agencies, State health departments, universities, and foreign governmental agencies. Pertinent original data and interpretive manuscripts are invited from investigators.

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U.S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
Public Health Service
Environmental Health Service
Bureau of Radiological Health

Strontium-90 and Cesium-137 in Total Diet Samples—A Comparative Study of Data

P. D. Roecklein, C. E. Smedley, and *R. E. Simpson*[1]

Six federal, State, and private organizations have published values for strontium-90 and cesium-137 activities in total diet samples for the period, January 1961 through December 1967. The data reported by these organizations have been statistically compared to determine how well the values of the several agencies agree. Our results show that there is agreement (at a significance level (α) equal to 0.05) in about 60 percent of the cases for comparable samples collected at about the same location and time and analyzed by similar methods. The 40 percent disagreement may be due to differences in samples, however, the specific sampling sites within a geographical area cannot be verified.

In 1961, the Food and Drug Administration began a surveillance program to monitor radioactivity in total diet samples (*1*). Similar programs were initiated in 1960 by the Health and Safety Laboratory (HASL) (*2*) and by the U.S. Public Health Service (*3*). In addition, several State public health agencies conducted programs locally starting in 1963 and 1964. Figure 1 shows the major sampling points throughout the country. Food categories in the total diets, in general, were based on a Department of Agriculture (USDA) study of food consumption in the United States (*4*).

A review of volumes 2 through 9 of *Radiological Health Data and Reports* showed that six total diet programs representing federal, State, and private organizations, had published sufficient data over a 7-year period so that the results could be compared. In addition to the above mentioned federal agencies, the States of California (*5*) and Connecticut (*6*), as well as the Consumers' Union (*7*), had programs that could be included in the comparison. With the exception of HASL and California, the programs monitored the radioactivity in total diets of children or teenagers, or in diets from institutions representing these age groups.

Summary of the programs

1. U.S. Food and Drug Administration, Radionuclides in Diets for Teenagers (*1*, *8*), May 1961 through November 1965.

Total diet samples were collected quarterly from nine FDA districts (figure 1). Food categories included 82 different items based on the USDA diet survey for 19-year-old boys (*4*). The foods were prepared in the district dietary kitchens and the edible portions combined and slurried for analysis.

A multichannel gamma-ray spectrometer was used to analyze aliquots of the slurry for cesium-137. Analysis for strontium-90 by beta-particle counting followed the standard procedures of the HASL Manual (*9*).

2. U.S. Public Health Service, Radionuclides in Institutional Total Diet Samples (*3*, *10*), January 1961 through December 1967.

---

[1] Mr. Simpson is head of the Radioactivity Section, Division of Food Chemistry and Technology, Bureau of Science, Food and Drug Administration; Mrs. Roecklein and Mr. Smedley, formerly with the Food and Drug Administration, were health physicists in the Radioactivity Section.

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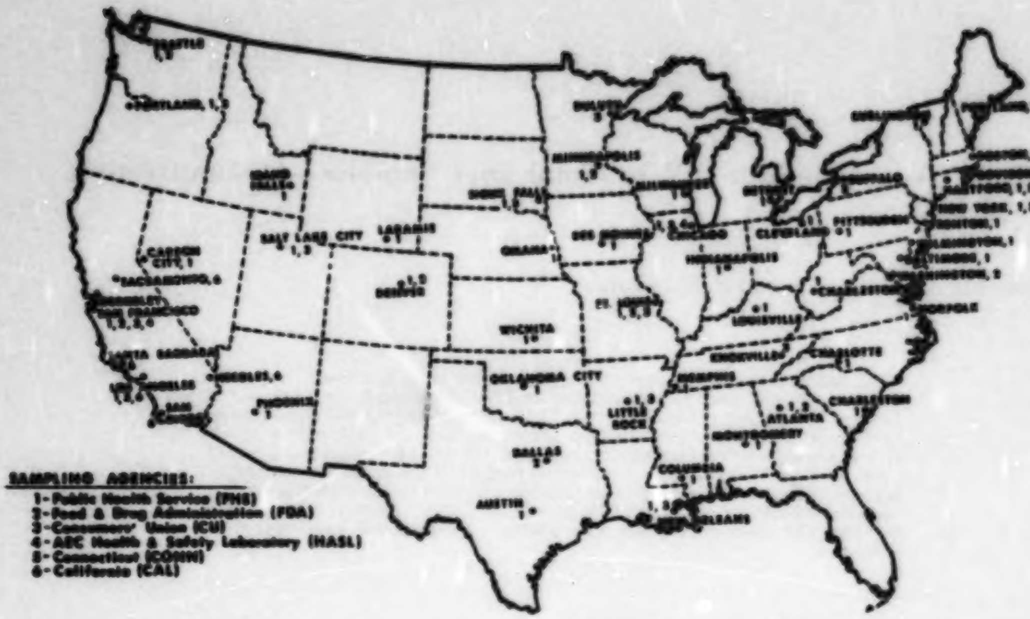
SEATTLE 1, 2
PORTLAND, 1, 2
IDAHO FALLS 1
SALT LAKE CITY 1, 2
LARAMIE 1
CARSON CITY, 1
SACRAMENTO, 6
BERKELEY
SAN FRANCISCO 1, 2, 3, 4
SANTA BARBARA
LOS ANGELES 1, 2, 6
SAN DIEGO
NEEDLES, 6
PHOENIX 1
DENVER 1, 2
SIOUX FALLS 1, 2
OMAHA 1
WICHITA 1
OKLAHOMA CITY 1
DALLAS 2
AUSTIN 1
DULUTH 2
MINNEAPOLIS 1, 2
MILWAUKEE 1
DES MOINES 1
CHICAGO 1, 2, 4
DETROIT 1
BUFFALO 1
CLEVELAND 1
PITTSBURGH
INDIANAPOLIS 1
ST. LOUIS 1, 2, 3
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CHARLESTON 1
KNOXVILLE
CHARLOTTE 1
MEMPHIS
LITTLE ROCK 1, 2
ATLANTA 1, 2
MONTGOMERY 1
COLUMBIA 1
NEW ORLEANS 1, 2
CHARLESTON 1
NORFOLK
WASHINGTON, 2
BALTIMORE, 1
WILMINGTON, 1
TRENTON, 1
NEW YORK, 1, 2, 4
HARTFORD, 1, 5
PROVIDENCE, 1
BOSTON, 1, 2, 3
PORTLAND, 1, 2
BURLINGTON
SAMPLING AGENCIES:
1- Public Health Service (PHS)
2- Food & Drug Administration (FDA)
3- Consumers' Union (CU)
4- AEC Health & Safety Laboratory (HASL)
5- Connecticut (CONN)
6- California (CAL)

Figure 1. Location of total diet sampling stations contributing data

Monthly samples were collected from boarding schools of various economic levels in the PHS sampling areas. The samples were representative of a 7-day week diet of children ages 9–12 and teenagers 13–18. The samples were analyzed for radium–226, cerium–144, barium–140, cesium–137, iodine–131, strontium–90, strontium–89, zinc–65, potassium–40, and stable calcium at the PHS regional laboratories. The gamma radioactivity in aliquots of slurried samples was measured with a gamma-ray spectrometer. After a radiochemical separation the radiostrontium activity in the samples was obtained by use of a low-background beta-particle counter.

3. Consumers Union, Selected Results from Total Diet Studies and Radionuclide Levels in Teenage Diets (*7*, *11*, *12*), May 1961 through June 1964.

Under PHS contract the Consumers' Union (CU) collected 7-day-week food samples for infants and teenage boys from different cities throughout the country. The samples were prepared in the dietary kitchens of selected universities, and split samples of the slurries were forwarded to CU contractor and PHS laboratories for a "cross-check" analysis of the radionuclides listed under the PHS study above. Samples handled by the CU contracting laboratories were radiochemically processed and all radionuclides assayed by beta-particle techniques.

4. AEC Health and Safety Laboratory, Tri-City Study (*2*, *13*), March 1960 through December 1967.

Samples were collected from 19 categories of food items in an average diet for the general populations of New York City, San Francisco, and Chicago. Each food item was analyzed separately for strontium–89, strontium–90, cesium–137, and stable calcium. The activity of each radionuclide was determined by beta-counting techniques after a radiochemical separation. The amounts of strontium–90 and cesium–137 in the total diet were obtained from an average of the results of the 19 categories, weighted according to the fractional contribution of these foods to the total diet.

5. California State Department of Public Health, Estimated Daily Intake of Radionuclides

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in California Diets (*5, 14*), January 1964 through December 1967.

The "house" diets of participating hospitals from 20 geographic areas were taken to be representative diets of the State's population. Seven-day week food samples were collected every 2 months for analysis by the State Sanitation and Radiation Laboratory. The samples were homogenized and ashed, and aliquots of the ash were assayed for strontium-89 and strontium-90 by beta-particle counting. The ashed portion was also analyzed for stable potassium, sodium, strontium, and calcium. Aliquots of the wet slurry were analyzed for cerium-144, cerium-141, cesium-137, and zirconium-95 by gamma-ray spectrometry.

6. Connecticut State Department of Health, Estimated Daily Intake of Radionuclides in Connecticut Standard Diet (*6, 15*), March 1963 through December 1967.

This diet was intended to be representative of one day's intake by an 18-year old boy. Samples were collected monthly throughout the State and analyzed for strontium-89, strontium-90, cesium-137, and normal potassium. A gamma-ray spectrometer was used to measure cesium-137 activity; dried and ashed aliquots of the sample were assayed for strontium-89 and strontium-90 using a thin-window gas-flow counter.

Statistical analysis

Of the variety of radionuclides reported in the total diets of the six programs, strontium-90 and cesium-137 are common to all programs. The reported levels of strontium-90 and cesium-137 activities per unit weight of total diet have been used as the basis for comparison.

Since detailed information regarding the geographic source of the total diet samples was often unavailable, it was assumed that the samples were representative of the immediate area around the cities where the collecting agency was located. In the study reported here, statistical comparisons are made only for data from agencies located in the same city or in cities less than 200 miles apart. The data used in our comparison are tabulated in tables 1 and 2 according to sampling time and location.

Frequently the precision of the results reproduced in tables 1 and 2 was not reported; therefore, the data have been treated as individual values. As such, the values cannot be considered as random samples from a normal distribution, and therefore, the only comparison of the data that may be made is between pairs of values as reported by two separate sponsors in the same geographic area and having similar sampling dates. The sign test for paired observations (*16*) is a distribution-free statistical comparison applicable under very general conditions and is therefore a suitable approach for data with the limitations noted above.

The sign test was applied to the hypothesis that values for strontium-90 or cesium-137 content in total diet samples as reported by two separate agencies agree with respect to time and place of sampling. Since the composition of the food samples and the methods of analysis were similar for all the sponsors included in this study, the statistical test should give a valid indication of significant differences in strontium-90 and cesium-137 activities reported. Initially the test was applied at the 0.25 level of significance; at this level there is a 25-percent chance of concluding that two sets of values differ when in actuality they do not. The test was repeated at the 0.10 and 0.05 levels where there are 10 percent and 5-percent chances, respectively, of concluding the values disagree when they actually do not. Tables 3 and 4 tabulate the results of the sign test.

The Wilcoxon signed-ranks test is a more powerful statistical test; however, it requires the assumption that the data are from a symmetrical distribution. While this assumption may be reasonable, in this case it cannot be proven. Assuming, however, that this requirement is satisfied the Wilcoxon signed-ranks test was applied to the data sets and, with a few exceptions, confirmed the results of the sign test at the 0.05 significance level as indicated in tables 3 and 4.

Discussion

The results of our statistical study of strontium-90 and cesium-137 data include comparisons of data reported by the same agency for different cities and comparisons of data reported by different agencies within the same city. For the purpose of this study it was arbitrarily assumed that data accumulated in cities no more than 200 miles apart should agree. However, the data in tables 3 and 4 indicate that, at the 0.05 significance level,

Table 1. Strontium-90 radioactivity

Area		Program[a]	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
			1961											
Vt:	Burlington	1 PHS												
Maine:	Portland	2 PHS												
		3 CU												
Mass:	Boston	4 PHS										7	8	
		5 FDA												
		6 CU					4							
R.I:	Providence	7 PHS												
Conn:	Hartford	8 PHS												
		9 CONN												
N.Y:	New York City	10 PHS	3	2	5	4	3	3		7	4	3	6	3
		11 HASL		3			6			5			6	
		12 CU					4							
N.J:	Trenton	13 PHS												
Del:	Wilmington	14 PHS												
Md:	Baltimore	15 PHS												
D.C:	Washington	16 FDA					4			4			4	
Va:	Norfolk	17 PHS												
N.Y:	Buffalo	18 CU												
Ohio:	Cleveland	19 PHS												
Mich:	Detroit	20 PHS												
Pa:	Pittsburgh	21 PHS												
W. Va:	Charleston	22 PHS												
Wis:	Milwaukee	23 PHS												
Ill:	Chicago	24 PHS					4					6	4	
		25 HASL				5			3			3		
		26 CU					3							
Ind:	Indianapolis	27 PHS												
Ky:	Louisville	28 PHS												
N.C:	Charlotte	29 PHS												
S.C:	Charleston	30 PHS												
Tenn:	Knoxville	31 CU					5							
Ga:	Atlanta	32 PHS			5	5	4	7	4	3	4	5	4	3
		33 FDA												
Ala:	Montgomery	34 PHS												
Miss:	Columbia	35 PHS												
La:	New Orleans	36 PHS												
		37 CU					3							
Ark:	Little Rock	38 PHS												
		39 CU												
Tenn:	Memphis	40 PHS										7	7	5
Mo:	St. Louis	41 PHS	7	6	2	3	3	1	3			2	5	
		42 FDA												
		43 CU												
Iowa:	Des Moines	44 PHS												
Nebr:	Omaha	45 PHS												
S.Dak:	Sioux Falls	46 PHS												
		47 CU					3							
Minn:	Minneapolis	48 PHS												
		49 FDA												
	Duluth	50 CU												
Kans:	Wichita	51 PHS												
Okla:	Oklahoma City	52 PHS												
Tex:	Dallas	53 FDA												
	Austin	54 PHS		4	4	4	4	2	6	5	6	4	3	2
Wyo:	Laramie	55 PHS												
Colo:	Denver	56 PHS	3	6	1	2	3	2	2	4	3	7	6	4
		57 FDA												
Idaho:	Idaho Falls	58 PHS												
Utah:	Salt Lake City	59 PHS											5	1
		60 CU												
Wash:	Seattle	61 PHS		6	2	4	1	3	1	3	3	3	6	0
		62 FDA												
Ore:	Portland	63 PHS												
		64 CU												
Nev:	Carson City	65 PHS												
Calif:	Sacramento	66 CAL												
	Berkeley	67 CAL												
	San Francisco	68 PHS												
		69 FDA												
		70 HASL	2			2		2			1			2
		71 CU												
	Santa Barbara	72 CAL												
	Los Angeles	73 PHS		3	1	2	2	2	5	2	4	1	14	1
		74 CU					2							
		75 CAL												
	San Diego	76 CAL												
	Needles	77 CAL												
Ariz:	Phoenix	78 PHS												

See footnotes at end of table.

in total diet samples (pCi/kg)

Program	1962												1963					
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1 PHS																		
2 PHS																		
3 CU			5			9								8		19		13
4 PHS	6	6	7	5	2	1	1	8	6	9	9	10	14	14	17	13		26
5 FDA																		
6 CU	5		8		6	8												
7 PHS																		
8 PHS																		
9 CONN															9			
10 PHS	4		4	4	3	1	5							15		10	16	
11 HASL				6		6		8			9			10			20	
12 CU	4		5		7	8								6	7	7	8	14
13 PHS																		
14 PHS																		
15 PHS																		
16 FDA		6			6			7			8			12			11	
17 PHS	6	7	6	9	8	11	8	6	12	13	8	12	12	9	11	13	14	17
18 CU	4				6									6		7		15
19 PHS	5	5	4	4	6	1	4	3	5	1	7	3	9	13	20	11		17
20 PHS																		
21 PHS																		
22 PHS																		
23 PHS																		
24 PHS				3	8	2	1	6	1									
25 HASL		4		5			7			8			8			8		
26 CU	3		4		3	5								7	7	7	8	12
27 PHS																		
28 PHS																		
29 PHS																		
30 PHS																		
31 CU	5		8		14	10								9	8	12	17	24
32 PHS	4	5	5	9	8	7	9	8	8	10	7	9	10	12	10	10	17	16
33 FDA					10			7			9			13			10	
34 PHS																		
35 PHS																		
36 PHS	9	9	12	12	16	15	14	12	13	17	12	13	15	11	30	23	24	14
37 CU	10		15		13	19								16	23	23	15	14
38 PHS																		
39 CU	3				5									13	15	18	23	25
40 PHS	6	4	9	9	12	7	13	12	7	14	8	10	6	12	13	17	14	20
41 PHS			6	5	3	10	14	13							10	14	36	11
42 FDA					10			9			9			7			8	
43 CU														8		8		19
44 PHS																		
45 PHS	2	4	1	1	5	2	9	10		11	5	9	12		4	11	14	32
46 PHS																		
47 CU	3		4		4	10								8	9	10	9	14
48 PHS				3	1	10	9	10	16	12	2	6	6	6	8	13	11	22
49 FDA					5			9			8			9			10	
50 CU														10	12	12	11	19
51 PHS																		
52 PHS																		
53 FDA																	13	
54 PHS	5	5	5	4	6	7	6	7	9	6	5	7	9	10	9	10	12	10
55 PHS																		
56 PHS		4	3	3	1	23	10	13	12	10	7	24	8	13	8		12	13
57 FDA																	7	
58 PHS																		
59 PHS	3	3	3	3	2				7	6	8	7	7	9	5	6	6	
60 CU	3				3													
61 PHS	3	4	7	4	9	12	12	9	9	7	23	17	9	12	11	11	16	15
62 FDA																	10	
63 PHS																		
64 CU	3				8									11	10	15	31	22
65 PHS																		
66 CAL																		
67 CAL																		
68 PHS																		
69 FDA					3			3			5			8			9	
70 HASL				3		3			3			4			5			10
71 CU	2				3									5	8	11	11	11
72 CAL																		
73 PHS	1	2	3	2	1						8	2	3	2	2	5	5	
74 CU	3		4		1	2								3	3	5	5	6
75 CAL																		
76 CAL																		
77 CAL																		
78 PHS																		

See footnotes at end of table.

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Table 1. Strontium-90 radioactivity

Area	Program[a]	1963						1964					
		July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
Vt: Burlington	1 PHS										14	16	28
Maine: Portland	2 PHS										22	20	23
	3 CU			19									
Mass: Boston	4 PHS	12	30	26	16	28	23	23	26	19	23	17	33
	5 FDA					13						7	
	6 CU												
R.I: Providence	7 PHS												
Conn: Hartford	8 PHS												
	9 CONN	14	13	16	16	13	17	15	13	16	14	12	16
N.Y: New York City	10 PHS	17		18	14	26	20	19		16	15		
	11 HASL		20			19			17			20	
	12 CU	25	20	40					16		13		16
N.J: Trenton	13 PHS												
Del: Wilmington	14 PHS									15	17	26	17
Md: Baltimore	15 PHS												25
D.C: Washington	16 FDA		11			13			17			15	
Va: Norfolk	17 PHS	13	12	12	16	16	15	12	13	11	16	15	18
N.Y: Buffalo	18 CU			16					13		15		20
Ohio: Cleveland	19 PHS	17	44	13	32	14	16	12	16	12	13	13	17
Mich: Detroit	20 PHS												17
Pa: Pittsburgh	21 PHS										14	19	22
W. Va: Charleston	22 PHS												
Wisc: Milwaukee	23 PHS											15	19
Ill: Chicago	24 PHS	56	14	14	14	18	21	15	16	15	15	19	15
	25 HASL	11			15			14			14		
	26 CU	12	12	11					12		11		11
Ind: Indianapolis	27 PHS												19
Ky: Louisville	28 PHS												23
N.C: Charlotte	29 PHS												27
S.C: Charleston	30 PHS												16
Tenn: Knoxville	31 CU	29	24	27					16		16		23
Ga: Atlanta	32 PHS	6	19	14	16	17	19	13	16	11			21
	33 FDA		18			19			25			28	
Ala: Montgomery	34 PHS												14
Miss: Columbia	35 PHS							23	25	35	38	34	33
La: New Orleans	36 PHS	16	20	20	20	23	21	21	26	31	34	31	25
	37 CU	23	23	21					23		26		24
Ark: Little Rock	38 PHS										23	30	28
	39 CU	29	23	23									
Tenn: Memphis	40 PHS	15	20	24	18	16	19	22	12	20	29	24	18
Mo: St. Louis	41 PHS		4	23	11	15	2	17	33	15	24	22	24
	42 FDA		17			16			10			15	
	43 CU			19					13		10	16	18
Iowa: Des Moines	44 PHS												19
Nebr: Omaha	45 PHS	16	14	1	13	12	17	15	17	22	22	22	20
S. Dak: Sioux Falls	46 PHS												
	47 CU	19	31	12									
Minn: Minneapolis	48 PHS	17	10	11	12	10	1	15	14	19	19	10	35
	49 FDA		18			15			13			12	
Duluth	50 CU	17	17	14									
Kans: Wichita	51 PHS												14
Okla: Oklahoma City	52 PHS											17	15
Tex: Dallas	53 FDA		10			13			13			14	
Tex: Austin	54 PHS	13	12	11	10	14	12	9	10	10	6	8	10
Wyo: Laramie	55 PHS										15	18	32
Colo: Denver	56 PHS	32	17	6	10	9	1	11	12	13	16	13	14
	57 FDA		7			10			12			14	
Idaho: Idaho Falls	58 PHS											40	31
Utah: Salt Lake City	59 PHS			12	14	4	16	12	14	16	41	27	14
	60 CU								14		13		14
Wash: Seattle	61 PHS	13	16	17	21	14	14	16	14	16	43	27	25
	62 FDA		10			16			13			17	
Ore: Portland	63 PHS												
	64 CU	24	15	15					15		18		20
Nev: Carson City	65 PHS												
Calif: Sacramento	66 CAL								[b]8		[b]6		[b]5
Berkeley	67 CAL								[b]7		[b]10		[b]5
San Francisco	68 PHS												
	69 FDA		6			6			7			7	
	70 HASL			7			8			9			9
	71 CU	7	8	6									
Santa Barbara	72 CAL								[b]2		[b]8		[b]8
Los Angeles	73 PHS		10		4	7	6	6	8	14	9	7	10
	74 CU	6	4	4					6		6		8
	75 CAL								[b]3		[b]5		[b]4
San Diego	76 CAL										[b]1		[b]10
Needles	77 CAL								[b]11				[b]6
Ariz: Phoenix	78 PHS												

See footnotes at end of table.

in total diet samples (pCi/kg)—Continued

Program[a]	1964						1965											
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS	20	19	12	10	13	18	14	15	14	14	16	16	13	20	10	11	10	14
2 PHS	21	23	15	16	17	19	17	13	17	12	15	17						
3 CU																		
4 PHS	18	21	14	15	16	15	19	12	18	11	9	14	10	12	10	9	10	7
5 FDA		17			8									11			12	
6 CU																		
7 PHS							15	12		12	8	13						
8 PHS	14	12	10	8	9	13	12	14	11	9	11	12						
9 CONN	15	19	15	14	12	12	13	11	15	14	18	15		14	13	16	11	11
10 PHS						11	14	16	12	12	18							
11 HASL		17			16			14			17			12			13	
12 CU	20																	
13 PHS		16	9	10	11	10	11	12	10	10	13	18						
14 PHS	13	14	17	13	13	11	12	12	14	12	12	14	14	10	13		10	11
15 PHS	21	18	18	15	15	15	15	14	14	14	17	18						
16 FDA		11						11			13			11			8	
17 PHS	18	16	13	17	20	14	17	15	14	14	21	14						
18 CU	18																	
19 PHS	14	12	12	12	12	12	12	10	13	15	10	11	12	8	9	6	[illegible]	12
20 PHS	11	13	8	10	10	12	13	13	12	12	8	7						
21 PHS	17	16	14	17	18	14	15	19	15	14	13	16	10	12	8	10	15	13
22 PHS	23	23	18	20	25	27	22	17	16	23	19	18						
23 PHS	8	13	11	8	9	8	9	10	11	11	10	11						
24 PHS	14	15	8	9	12	12	12	15	14	9	13	11	9	9	9	15	9	8
25 HASL	13			12			10			12			9			9		
26 CU	12																	
27 PHS	15	11	14	11	11	9	11	14	11	14	13	12						
28 PHS	14	24	19	25	14	21	19	19	16	18	13	16	12	12	10	14	15	15
29 PHS	19	26	28	25	32	21	14	19	14	13	17	14						
30 PHS	16	12	22	17	19		25	14	16	19	21	14	15	20	18	18	16	21
31 CU	22																	
32 PHS	21	18	10	26	27	28	16	10	19	18	19	18						
33 FDA		20			21						17			12			12	
34 PHS	13	12	9	13	15	17	11	14	11	12	14	10						
35 PHS	34	27	28	41	33	23	26	18	22	23	22	18						
36 PHS	31	26	21	22	21	25	17	13	19	19	18	19	24	17	22	14	19	16
37 CU	27																	
38 PHS	22	21	20	28	19	27	20	20	22	28	24	19	26	17	24	20	12	20
39 CU																		
40 PHS	23	29	20	13	16	14	16	13	14	22	17	16						
41 PHS	18	17	6	22	20	15	36	22	27	15	25	16	14	13	11	12	10	11
42 FDA		18			8						12			12			0	
43 CU																		
44 PHS	23	19	18	22	15	14	13	13	14	17	15	12						
45 PHS	22	18	21	16	23	13	19	25	21	22	20	16						
46 PHS						19	19	22	13	8	15	22	17	16	12	16	15	19
47 CU																		
48 PHS	17	17						53	38	17	24	19						
49 FDA		10			9			14			16			14			17	
50 CU																		
51 PHS	14	12	17	9	10	14	15	16	16	10	12	12						
52 PHS	8	8	15	14	16	16	16	11	14	12	12	10						
53 FDA		11			10			8			11			8			8	
54 PHS	10	16	11	8	15	10	8	8	6	8	8	6	8	8	12	6	8	8
55 PHS	20	22	13	12	13	15	12	16	14	13	18	19						
56 PHS	16	16	7	16	8	10	18	20	19	17	12	17	11	9	8	8	11	16
57 FDA		11			7			9			17			19			24	
58 PHS	22	20	24	13		16	16	36	25	27	29	20	34	12	9	17	14	10
59 PHS			21	15	6	14	9	14	16	13	18	15						
60 CU	13																	
61 PHS	26	22	11	15	32	21	36	18	20	19	34	18	20	23	15	26	12	15
62 FDA		13			14			11			17			8			9	
63 PHS	13	12	20	11	10	11	16	24	10	9	17	14						
64 CU	17																	
65 PHS			23	10	10	17	11	46	25	9	7	11						
66 CAL		[b]9		[b]6		[b]6		[b]4		[b]1		[b]8		[b]6		[b]5		[b]6
67 CAL		[b]7		[b]13		[b]4		[b]8		[b]5		[b]7		[b]4		[b]5		[b]5
68 PHS										11	18	9						
69 FDA		6			6			6			6			5			4	
70 HASL			6			6			8			7			5			5
71 CU																		
72 CAL		[b]13		[b]8				[b]7		[b]9		[b]5		[b]7		[b]3		
73 PHS				8	8	18	8	17	13	5	7	7	9	7	6	4	6	11
74 CU	5																	
75 CAL		[b]4		[b]10		[b]4		[b]5		[b]3		[b]4		[b]3		[b]3		[b]4
76 CAL		[b]2		[b]4		[b]6		[b]4		[b]6		[b]6		[b]6		[b]3		[b]4
77 CAL		[b]11		[b]17		[b]7		[b]4		[b]5		[b]4		[b]5		[b]5		[b]7
78 PHS							18	28	20	18	19	11	6	2	13	13	8	14

Table 1. Strontium-90 radioactivity

Area	Programᵃ	1966 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept
Vt: Burlington	1 PHS	12	13	11	11	16	13	15	7	9
Maine: Portland	2 PHS									
	3 CU									
Mass: Boston	4 PHS	8	7	7	8	7	9	9		8
	5 FDA									
	6 CU									
R.I: Providence	7 PHS									
Conn: Hartford	8 PHS									
	9 CONN	11	12	12	14	10	16	10	9	9
N.Y: New York City	10 PHS									
	11 HASL		11			12			11	
	12 CU									
N.J: Trenton	13 PHS									
Del: Wilmington	14 PHS	11	10	11	9	10	11		10	10
Md: Baltimore	15 PHS									
D.C: Washington	16 FDA					14			10	
Va: Norfolk	17 PHS									
N.Y: Buffalo	18 CU									
Ohio: Cleveland	19 PHS	9	9	11	10	7	11	7	7	9
Mich: Detroit	20 PHS									
Pa: Pittsburgh	21 PHS	12	10	10	10	9	11	12	9	9
W. Va: Charleston	22 PHS									
Wisc: Milwaukee	23 PHS									
Ill: Chicago	24 PHS	7	9	9	8	8	12	6	6	6
	25 HASL	11			9			9		
	26 CU									
Ind: Indianapolis	27 PHS									
Ky: Louisville	28 PHS	13	16	14	13	16	19			13
N.C: Charlotte	29 PHS									
S.C: Charleston	30 PHS	20	13	15	13	12	14	12	14	14
Tenn: Knoxville	31 CU									
Ga: Atlanta	32 PHS									
	33 FDA									
Ala: Montgomery	34 PHS									
Miss: Columbia	35 PHS									
La: New Orleans	36 PHS	19	16	17	18	21	22	16	18	16
Ark: Little Rock	37 CU									
	38 PHS	12	20	14	12	14	18	18	15	18
	39 CU									
Tenn: Memphis	40 PHS									
Mo: St. Louis	41 PHS	10	11	11	10	12	17			
	42 FDA					11			10	
	43 CU									
Iowa: Des Moines	44 PHS									
Nebr: Omaha	45 PHS									
S. Dak: Sioux Falls	46 PHS	14	13	14	17	14	12	13		
	47 CU									
Minn: Minneapolis	48 PHS									
	49 FDA									
Duluth	50 CU									
Kans: Wichita	51 PHS									
Okla: Oklahoma City	52 PHS									
Tex: Dallas	53 FDA									
Tex: Austin	54 PHS	8	7	7	6	6	10	7	8	7
Wyo: Laramie	55 PHS									
Colo: Denver	56 PHS	15	10	12	11	16	8	8	8	11
	57 FDA									
Idaho: Idaho Falls	58 PHS	9	16	11	8	25	6	6	9	9
Utah: Salt Lake City	59 PHS									
	60 CU									
Wash: Seattle	61 PHS	10	17	12	20	18	29	15		15
	62 FDA									
Ore: Portland	63 PHS									
	64 CU									
Nev: Carson City	65 PHS									
Calif: Sacramento	66 CAL		ᵇ 6		ᵇ 4		ᵇ 4		ᵇ 5	
Berkeley	67 CAL		ᵇ 3		ᵇ 5		ᵇ 3		ᵇ 4	
San Francisco	68 PHS									
	69 FDA					4			4	
	70 HASL			5			3			3
	71 CU									
Santa Barbara	72 CAL		ᵇ 5		ᵇ 7		ᵇ 4		ᵇ 4	
Los Angeles	73 PHS	7	8	16	7	12	6	6	6	11
	74 CU									
	75 CAL		ᵇ 6		ᵇ 4		ᵇ 5		ᵇ 3	
San Diego	76 CAL		ᵇ 1		ᵇ 4		ᵇ 3		ᵇ 3	
Needles	77 CAL		ᵇ 5		ᵇ 5		ᵇ 3		ᵇ 5	
Ariz: Phoenix	78 PHS	10	14	11	7	11	12	10	4	6

ᵃ Agency symbols identified in figure 1. See beginning of table for a breakdown of area by using the program code.
ᵇ Bimonthly samples include preceding month.

in total diet samples (pCi/kg)—Continued

Program[a]	1966			1967											
	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS	12	12	10	13	12	11	13	11	8		16	12			
2 PHS													10	10	14
3 CU															
4 PHS	11	10	11	11	12	10	10	11	11	11		10	9	8	13
5 FDA															
6 CU															
7 PHS															
8 PHS															
9 CONN	13	9	11	10	9		10	8	11	9		13	10		8
10 PHS															
11 HASL		7			8			10			10			10	
12 CU															
13 PHS															
14 PHS	10	11	8	10	9	10	9	8	12	16	9	10	10	8	7
15 PHS															
16 FDA		11			12										
17 PHS															
18 CU															
19 PHS	7	7	8	9	7	8	7	9	7	8	8	5	6	6	7
20 PHS															
21 PHS	9	10	9	8	8	7	10	7	10	6	7	7	6	8	8
22 PHS															
23 PHS															
24 PHS	7	7	8	7	7	7	7	8	8	7	8	5	5	7	7
25 HASL	5			8			7			7			6		
26 CU															
27 PHS															
28 PHS	8	11	10	9	10	12	11	12	12	8	9	7	9	9	9
29 PHS															
30 PHS	10	11	14	13	15	12	9	11	8	9	8	11	9	11	12
31 CU															
32 PHS															
33 FDA															
34 PHS															
35 PHS										6	10	9	11	14	12
36 PHS	17	17	9	13	13	17	12	14	10	11	12	13	10	12	12
37 CU															
38 PHS	13	11	15	13	13	13	10	14	13	20	17	15	10	9	10
39 CU															
40 PHS															
41 PHS		11	8	[illegible]	11	11	11	15	14					12	8
42 FDA		9													
43 CU															
44 PHS															
45 PHS										6	8	6	7	6	5
46 PHS		6	5	5	6	17	6	8	6	7	7	5	7	5	4
47 CU															
48 PHS															
49 FDA															
50 CU															
51 PHS															
52 PHS															
53 FDA															
54 PHS	7	7	7	8	6	5	5	5	5	3	8	5	4	6	7
55 PHS															
56 PHS	7	9	6	7	8	8	7	7	6	6	6	4	8	3	7
57 FDA															
58 PHS	12	9	13	11	11	8	8	7	2	6	14	9	7	7	7
59 PHS										4	4	4	6	6	5
60 CU															
61 PHS	18	16	7	8	10	6	8	11	7		7	6	5	6	4
62 FDA															
63 PHS										5	5	4	6	5	3
64 CU															
65 PHS										5	4	6	6	2	6
66 CAL	[b]4		[b]2		[b]3		[b]4		[b]4		[b]3		[b]2		
67 CAL	[b]4		[b]3		[b]3		[b]2		[b]2		[b]2		[b]3		
68 PHS										6	3	6	3	11	4
69 FDA		3			3										
70 HASL			2			4			4			2			2
71 CU															
72 CAL	[b]3		[b]5		[b]4		[b]2		[b]2		[b]4		[b]2		
73 PHS	6	6	6	5	5	4	4	5	5	4	6	4	3	3	6
74 CU															
75 CAL	[b]5		[b]3		[b]3		[b]5		[b]4		[b]2		[b]2		
76 CAL	[b]6		[b]3		[b]3				[b]2		[b]2		[b]2		
77 CAL	[b]3		[b]3		[b]3		[b]2		[b]2		[b]3		[b]2		
78 PHS	9	7	5	6	5	3	7	4	7	4	3	8	12	11	

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Table 2. Cesium-137 radioactivity in

Area	Program[a]	1961 Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
Vt.: Burlington	1 PHS												
Maine: Portland	2 PHS												
	3 CU												
Mass: Boston[b]	4 PHS										15	5	
	5 FDA												
R.I.: Providence	6 PHS												
Conn: Hartford	7 PHS												
	8 CONN												
N.Y.: New York City	9 PHS	46	2	5		14	8		10	14	5	5	5
	10 HASL												
	11 CU					28							
N.J.: Trenton	12 PHS												
Del: Wilmington	13 PHS												
Md: Baltimore	14 PHS												
D.C.: Washington	15 FDA												
Va: Norfolk	16 PHS												
N.Y.: Buffalo	17 CU												
Ohio: Cleveland	18 PHS												
Mich: Detroit	19 PHS												
Pa: Pittsburgh	20 PHS												
W.VA: Charleston	21 PHS												
Wisc: Milwaukee	22 PHS												
Ill: Chicago	23 PHS					16					5	6	
	24 HASL												
	25 CU					45							
Ind: Indianapolis	26 PHS												
Ky: Louisville	27 PHS												
N.C.: Charlotte	28 PHS												
S.C.: Charleston	29 PHS												
Tenn: Knoxville	30 CU					41							
Ga: Atlanta	31 PHS			6	13	6	10	8	5	5	10	5	5
	32 FDA												
Ala: Montgomery	33 PHS												
Miss: Columbia	34 PHS												
La: New Orleans	35 PHS												
	36 CU					40							
Ark: Little Rock	37 PHS												
	38 CU												
Tenn: Memphis	39 PHS										14	5	5
Mo: St. Louis	40 PHS	5	6	5	4	22	11	10			10	10	
	41 FDA												
	42 CU												
Iowa: Des Moines	43 PHS												
Nebr: Omaha	44 PHS												
S.Dak: Sioux Falls	45 PHS												
	46 CU					26							
Minn: Minneapolis	47 PHS												
	48 FDA												
Minn: Duluth	49 CU												
Kans: Wichita	50 PHS												
Okla: Oklahoma City	51 PHS												
Tex: Dallas	52 FDA												
Austin	53 PHS		5	5	9	5	9	5	5	5	5	5	5
Wyo: Laramie	54 PHS												
Colo: Denver	55 PHS	5	5	8	10	35	11	10	20	5	5	5	10
	56 FDA												
Idaho: Idaho Falls	57 PHS												
Utah: Salt Lake City	58 PHS											5	10
	59 CU												
Wash: Seattle	60 PHS		4	12	5	22	18	20	15	20	15	15	15
	61 FDA												
Ore: Portland	62 PHS												
	63 CU												
Nev: Carson City	64 PHS												
Calif: Sacramento	65 CAL												
Berkeley	66 CAL												
San Francisco	67 PHS												
	68 FDA												
	69 HASL												
	70 CU												
Santa Barbara	71 CAL												
Los Angeles	72 PHS		5	5	4	4	5	20	15	10	5	5	5
	73 CU					16							
	74 CAL												
San Diego	75 CAL												
Needles	76 CAL												
Ariz: Phoenix	77 PHS												

See footnotes at end of table.

total diet samples (pCi/kg)

Program*	1968												1969							
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug
1 PHS																				
2 PHS																				
3 CU			61			154								25		90		90		
4 PHS	25	5	9	25	35	76	108	41	27	65	118	117	94	61	91	61	68	125	155	216
5 FDA																				
6 PHS																				
7 PHS																				
8 CONN															60				80	130
9 PHS	6		6	10	4	50	30							51		66	65		75	
10 HASL											34									
11 CU	51		57		68	133								45	30	50	45	79	116	120
12 PHS																				
13 PHS																				
14 PHS																				
15 FDA					12			39			37			51			73			74
16 PHS	5	5	7	15	45	14	16	29	34	34	30	34	33	34	33	89	39	41	68	53
17 CU	31				68									80		50		70		
18 PHS	5	5	10	14	16	57	130	90	18	56	46	79	69	55	42	59	61	85	84	96
19 PHS																				
20 PHS																				
21 PHS																				
22 PHS																				
23 PHS				5	12	90	37	6	113										81	78
24 HASL										31										
25 CU	37		60		46	127								29	40	41	45	70	76	84
26 PHS																				
27 PHS																				
28 PHS																				
29 PHS																				
30 CU	29		68		143	167								35	35	44	40	79	105	126
31 PHS	5	16	24	33	7	29	12	33	35	6	19	30	29	40	39	38	113	78	96	101
32 FDA					29			16			23			45			120			78
33 PHS																				
34 PHS																				
35 PHS	7	14	24	40	84	44	20	40	44	60	30	50	54	70	90	105	100	102	85	115
36	107		150		153	325								50	70	65	90	50	70	
37 PHS																				
38 CU	29				69									34	51	60	79	100	100	106
39 PHS	5	5	6	15	5	10	12	19	12	11	21	24	41	40	49	26	41	65	76	92
40 PHS			2	2	5	25	40	34							39	34	208	80		55
41 FDA					33			13			34			31						80
42 CU														35		30		80		
43 PHS																				
44 PHS	5	10	5	3	6	3	16	40		24	21	33	59		41	89	70	76	61	74
45 PHS																				
46 CU	22		43		77	141								55	45	55	46	80	79	
47 PHS				3	3	36	36	55	29	40	40	37	50	55	67	64	48	90	80	101
48 FDA					13			21			28			62			114			109
49 CU			53			285								60	60	75	50	105	90	95
50 PHS																				
51 PHS																				
52 FDA																	100			66
53 PHS	13	5	14	27	35	22	15	19	20	19	40	39	50	24	30	50	37	52	58	53
54 PHS																				
55 PHS		10	10	2	10	6	74	10	43	50	45	101	69	61	73		60	55	85	34
56 FDA																	79			94
57 PHS																				
58 PHS	5	10	15	4	3				35	49	35	36	35	90	80	42	64			
59 CU	21				26															
60 PHS	10	10	10	12	60	65	55	75	40	40	39	30	70	76	70	60	99	96	111	116
61 FDA																	113			106
62 PHS																				
63 CU	34				202									40	45	61	115	111	160	94
64 PHS																				
65 CAL																				
66 CAL																				
67 PHS																				
68 FDA					1			14			9			16			76			42
69 HASL												18								
70 CU	29				53									10	30	49	49	65	70	96
71 CAL																				
72 PHS	15	5	3	3	3						4	13	24		25	31	30			33
73 CU	58		47		23	24								10	24	20	20	35	35	45
74 CAL																				
75 CAL																				
76 CAL																				
77 PHS																				

See footnotes at end of page.

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Table 2. Cesium-137 radioactivity in

Program[a]	1963				1964											
	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS								115	125	140	105	95	85	70	75	90
2 PHS								140	130	125	150	130	95	90	105	100
3 CU	121															
4 PHS	190	129	188	172	215	200	170	165	150	200	155	125	110	105	90	115
5 FDA			99			119			108			92			96	
6 PHS																
7 PHS											90	100	70	70	70	90
8 CONN	120	100	110	140	140	110	150	160	90	120	130	110	100	100	80	70
9 PHS	86	76	100	129	85		115	115								75
10 HASL			85													
11 CU	110					82		98	92	117						
12 PHS												55	50	85	70	10
13 PHS							110	120	145	105	70	70	70	85	65	65
14 PHS										95	80	55	45	50	50	60
15 FDA			55			82			97			59				
16 PHS	73	50	63	66	60	60	60	65	60	75	60	50	55	55	60	45
17 CU	85					95		96	96	100						
18 PHS	73	63	75	102	95	100	105	100	100	95	80	80	70	65	70	60
19 PHS										95	75	90	70	75	65	70
20 PHS								110	100	100	85	80	65	75	80	70
21 PHS											60	60	40	65	70	70
22 PHS									110	95	85	75	70	70	60	65
23 PHS	96	66	105	121	120	110	120	100	110	90	85	75	70	65	70	70
24 HASL		63														
25 CU	70					77		85	88	71						
26 PHS										80	60	60	60	55	60	75
27 PHS										55	40	45	30	30	40	45
28 PHS										70	45	50	45	55	55	55
29 PHS										105	55	60	78	50	80	
30 CU	60					85		99	120	78						
31 PHS	91	66	77	76	60	55	55			75	55	50	65	70	60	60
32 FDA			63			91			125			51			83	
33 PHS										50	50	40	50	45	45	50
34 PHS					110	120	200	230	190	135	105	85	65	75	90	70
35 PHS	95	94	116	120	110	140	140	110	115	85	80	65	60	50	60	45
36 CU	65					96		128	95	84						
37 PHS								85	115	75	50	60	45	50	50	35
38 CU	74															
39 PHS	51	48	76	60	65	55	65	60	55	50	40	40	40	40	25	45
40 PHS	60	70	69	79	60	75	70	70	65	55	50	55	55	55	45	80
41 FDA						67			83			39			55	
42 CU	40					74		85	80	77						
43 PHS										65	55	60	60	60	45	55
44 PHS	59	81	70	71	65	70	80	100	125	60	70	50	45	40	45	55
45 PHS																90
46 CU	65															
47 PHS	86	79	86	90	95	110	110	100	75	95	75	80				
48 FDA			83			103			87			102			68	
49 CU	90															
50 PHS										70	30	80	45	35	40	35
51 PHS									65	55	35	20	45	40	45	40
52 FDA			44						56			40			56	
53 PHS	31	51	67	59	45	45	30	30	50	40	35	25	35	30	30	25
54 PHS								90	65	80	65	60	55	55	65	80
55 PHS	55	74	54	45	65	70	50	80	60	65	90	70	50	50	30	55
56 FDA			57			70			84			59			37	
57 PHS									180	195	125	95	120	50		100
58 PHS	40	123	119	175	135	140	140	155	125	90			80	75	50	85
59 CU						124		140	122	119						
60 PHS	120	99	121	84	110	90	100	90	90	110	140	120	120	85	95	100
61 FDA			95			64			104			86			97	
62 PHS											55	55	70	55	55	80
63 CU	85					165		160	165	131						
64 PHS													50	45	55	50
65 CAL						[d]30		[d]33		[d]25		[d]16		[d]30		[d]34
66 CAL						[d]31		[d]33		[d]21		[d]20		[d]24		[d]22
67 PHS																
68 FDA			57			63			63			34			43	
69 HASL				150												
70 CU	40															
71 CAL								[d]33				[d]26		[d]20		
72 PHS		50	60	50	65	70	50	50	55	50				55	20	35
73 CU	45					55		50	65	41						
74 CAL								[d]32		[d]23		[d]17		[d]42		[d]28
75 CAL						[d]22		[d]20		[d]32		[d]21		[d]35		[d]18
76 CAL						[d]56				[d]27		[d]30		[d]25		[d]25
77 PHS																

See footnotes at end of table.

total diet samples (pCi/kg)—Continued

Program[a]	1965												1966					
	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June
1 PHS	80	90	90	95	100	80	65	60	40	40	40	40	65	40	45	50	55	60
2 PHS	100	85	95	85	95	70												
3 CU																		
4 PHS	115	80	105	65	95	65	40	50	35	30	35	40	45	25	35	25	35	30
5 FDA		50			64			51			41							
6 PHS	80	75		85	80	60												
7 PHS	95	90	65	80	90	50												
8 CONN	70	60	80	70	120	70	60	70	50	60	50	30	50	30	60	40	30	40
9 PHS	90	70	65	75	70													
10 HASL		108			104						77							
11 CU																		
12 PHS	60	65	70	65	45	50												
13 PHS	60	80	80	55	85	55	50	30	35		25	40	35	40	40	25	25	25
14 PHS	40	50	50	45	60	50												
15 FDA		49			55			35			24							
16 PHS	45	40	40	55	45	35												
17 CU																		
18 PHS	85	70	70	65	55	75	40	40	50	25	35	60	35	55	40	80	40	80
19 PHS	70	65	85	75	70	55												
20 PHS	70	75	60	70	60	60	35	40	40	40	30	35	45	30	30	35	40	25
21 PHS	65	70	50	60	45	45												
22 PHS	65	80	60	75	70	55												
23 PHS	85	80	85	70	75	60	30	30	40	50	40	45	45	45	40	35	40	30
24 HASL	80			70			56			66								
25 CU																		
26 PHS	60	70	70	65	55	40												
27 PHS	50	40	35	35	25	30	35	30	30	30	30	25	25	25	30	25	55	30
28 PHS	50	40	35	50	50	20												
29 PHS	75	60	70	65	75	50	40	55	55	40	40	40	45	40	35	25	25	50
30 CU																		
31 PHS	65	70	70	75	50	45												
32 FDA		52			47			38			38							
33 PHS	45	40	45	25	50	25												
34 PHS	75	70	70	75	70	60												
35 PHS	100	55	60	55	50	40	45	40	40	35	45	40	35	40	30	40	35	45
36 CU																		
37 PHS	50	45	40	40	45	30	40	25	30	25	25	25	20	30	20	25	30	25
38 CU																		
39 PHS	40	35	40	45	35	40												
40 PHS	45	55	80	30	20	25	30	25	45	30	35	30	40	30	35	30	30	35
41 FDA		35			28													
42 CU																		
43 PHS	60	60	50	60	70	30												
44 PHS	35	55	55	75	55	60												
45 PHS	95	75	85	70	70	75	75	50	60	75	70	85	70	40	60	65	40	35
46 CU																		
47 PHS		65	80	45	80	60												
48 FDA		63			66			56			42							
49 CU																		
50 PHS	45	50	50	50	40	40												
51 PHS	45	35	40	30	35	20												
52 FDA		30			26			19			21							
53 PHS	20	30	30	25	20	30	20	25	30	15	20	25	20	15	25	25	15	25
54 PHS	65	45	55	65	50	75												
55 PHS	35	45	40	85	35	65	55	30	35	45	40	25	30	20	10	30	30	20
56 FDA		33			40			30			26							
57 PHS	80	140	125	120	85	55	65	65	40	40	45	30	45	35	40	30	30	30
58 PHS	75	60	65	75	45	75												
59 CU																		
60 PHS	105	70	80	65	75	70	80	60	60	55	50	45	50	70	40	65	40	50
61 FDA		48						54			37							
62 PHS	30	45	40	60	60	55												
63 CU																		
64 PHS	40	40	40	55	35	45												
65 CAL		[d]27		[d]29		[d]32		[d]30		[d]22		[d]25		[d]18		[d]12		[d]15
66 CAL		[d]29		[d]22		[d]30		[d]33		[d]23		[d]21		[d]17		[d]18		[d]14
67 PHS				30	35	40												
68 FDA		29						33			22							
69 HASL			74			50			40			52						
70 CU																		
71 CAL		[d]31		[d]38		[d]30		[d]29		[d]32				[d]33		[d]13		[d]14
72 PHS	35	55	20	25	30	30	30	25	40	35	15	35	20	30	20	20	25	25
73 CU																		
74 CAL		[d]35		[d]30		[d]29		[d]22				[d]16		[d]17		[d]23		[d]15
75 CAL		[d]25		[d]29		[d]25		[d]26		[d]28		[d]13		[d]27		[d]13		[d]18
76 CAL		[d]29		[d]27		[d]30		[d]24		[d]24		[d]23		[d]19		[d]13		[d]11
77 PHS	75	100	80	45	60	30	35	15	50	40	35	25	25	35	25	20	20	30

See footnotes at end of table.

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Table 2. Cesium-137 radioactivity in total diet samples—Continued
(pCi/kg)

Program[a]	1966						1967											
	July	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sept	Oct	Nov	Dec
1 PHS	45	40	30	30	40	30	30	20	30	15	20	15		26	25			
2 PHS																22	25	26
3 CU																		
4 PHS	30		25	25	25	30	35	25	30	30	25	15	23		19	24	28	17
5 FDA																		
6 PHS																		
7 PHS																		
8 CONN	30	30	30	10	30	30	30	20		30	10	20	30		20	20		10
9 PHS																		
10 HASL																		
11 CU																		
12 PHS																		
13 PHS		25	25	25	25	25	15	25	20	10	15	30	17	14	[c]0	[c]0	19	14
14 PHS																		
15 FDA																		
16 PHS																		
17 CU																		
18 PHS	30	20	30	20	25	15	25	15	25	10	20	20	[c]0	12	[c]0	11	[c]0	11
19 PHS																		
20 PHS	30	20	15	25	25	20	25	20	25	20	10	10	16	[c]0	20	[c]0	24	18
21 PHS																		
22 PHS																		
23 PHS	20	15	20	25	25	25	15	20	20	10	15	15	22	18	11	15	15	24
24 HASL																		
25 CU																		
26 PHS																		
27 PHS			15	15	20	15	20	15	15	15	10	15	[c]0	14	[c]0	12	[c]0	[c]0
28 PHS																		
29 PHS	35	30	40	25	30	25	25	25	20	30	20	30	46	26	21	26	18	16
30 CU																		
31 PHS																		
32 FDA																		
33 PHS																		
34 PHS													18	20	20	18	19	[c]0
35 PHS	35	35	35	25	20	10	25	10	20	15	35	20	25	22	26	18	19	14
36 CU																		
37 PHS	20	15	20	15	15	10	20	15	20	20	15	20	15	17	23	14	[c]0	[c]0
38 CU																		
39 PHS																		
40 PHS					20	10	20	15	25	10	15	10					16	13
41 FDA																		
42 CU																		
43 PHS																		
44 PHS													11	[c]0	15	[c]0	16	[c]0
45 PHS	35				25	15	20	25	20	15	20	15	[c]0	[c]0	[c]0	14	15	15
46 CU																		
47 PHS																		
48 FDA																		
49 CU																		
50 PHS																		
51 PHS																		
52 FDA																		
53 PHS	15	15	10	15	5	15	15	5	10	10	5	15	[c]0	[c]0	[c]0	[c]0	[c]0	[c]0
54 PHS																		
55 PHS	20	25	20	15	5	10	25	5	15	15	15	25	15	13	11	19	13	14
56 FDA																		
57 PHS	[illegible]	35	30	30	30	20	30	25	10	10	20	15	12	26	[c]0	10	14	13
58 PHS													11	[c]0	11	12	[c]0	[c]0
59 CU																		
60 PHS	40		40	5	45	40	45	20	10	15	35	30	18	[c]0	30	20	12	22
61 FDA																		
62 PHS													17	21	20	19	31	12
63 CU																		
64 PHS													20	[c]0	17	17	15	[c]0
65 CAL		[d]16		[d]10		[d]6		[d]8		[d]7		[d]10		[d]2		[d]6		
66 CAL		[d]14		[d]16		[d]8		[d]16		[d]12		[d]7		[d]5		[d]6		
67 PHS													19	11	15	11	12	[c]0
68 FDA																		
69 HASL																		
70 CU																		
71 CAL		[d]11		[d]11		[d]9		[d]8		[d]5		[d]4		[d]6		[d]8		
72 PHS	25	20	25	25	30	20	15	20	10	15	10	10	[c]0	12	12	[c]0	[c]0	[c]0
73 CU																		
74 CAL		[d]11		[d]15		[d]15		[d]11		[d]7		[d]9		[d]8		[d]8		
75 CAL		[d]15		[d]12		[d]8		[d]13				[d]14		[d]5		[d]6		
76 CAL		[d]12		[d]11		[d]9		[d]7		[d]6		[d]6		[d]4		[d]5		
77 PHS	10	20	5	15	15	10	10	5	5	15	10	10	15	11	11	[c]0	15	

[a] Agency symbols identified in figure 1. See beginning of table for a breakdown of area by using the program code.
[b] The Consumers Union data from the Boston, Mass., station were not used because sufficient data pairs could not be formed for a valid comparison.
[c] Zero indicates a value less than the minimum detectable level of 10 pCi/kg.
[d] Bimonthly samples includes preceding month.

Table 3. Results of the sign test for paired observations applied to strontium-90 data[a]

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Portland, Maine)—PHS (Burlington)	15	−	+	[b] +
CU (Portland, Maine)—PHS (Boston)	6	−	+	+
PHS (Portland, Maine)—PHS (Boston)	16	−	−	−
PHS (Boston)—FDA (Boston)	6	−	+	+
PHS (Portland, Maine)—CONN (Hartford)	15	−	−	−
PHS (Portland, Maine)—PHS (Hartford)	12	−	−	−
CONN (Hartford)—PHS (Hartford)	12	−	−	−
PHS (Burlington)—PHS (Boston)	35	−	−	+
PHS (Burlington)—FDA (Boston)	5	+	+	0
PHS (Burlington)—CONN (Hartford)	34	+	+	+
PHS (Burlington)—PHS (Hartford)	11	−	−	−
FDA (Boston)—CONN (Hartford)	5	+	+	0
PHS (Boston)—CONN (Hartford)	46	+	+	+
PHS (Boston)—PHS (Hartford)	12	−	−	−
CU (Boston)—PHS (New York)	5	−	−	0
FDA (Boston)—HASL (New York)	5	−	−	0
PHS (Boston)—CU (New York)	15	+	+	+
PHS (Boston)—PHS (New York)	23	−	−	+
PHS (Boston)—HASL (New York)	18	+	+	+
CU (New York)—PHS (New York)	10	+	+	+
CU (New York)—HASL (New York)	5	+	+	0
PHS (New York)—HASL (New York)	10	+	+	+
PHS (Providence)—CONN (Hartford)	5	+	+	0
PHS (Providence)—PHS (Hartford)	5	+	+	0
CONN (Hartford)—CU (New York)	7	+	+	+
CONN (Hartford)—PHS (New York)	12	+	+	+
CONN (Hartford)—HASL (New York)	16	+	+	[b] +
PHS (Hartford)—PHS (New York)	6	−	+	+
CONN (Hartford)—PHS (Trenton)	11	−	−	[b] +
PHS (Hartford)—PHS (Trenton)	11	+	+	+
PHS (New York)—PHS (Trenton)	6	−	−	−
PHS (New York)—PHS (Wilmington)	6	+	+	+
HASL (New York)—PHS (Wilmington)	15	−	−	[b] −
PHS (New York)—PHS (Baltimore)	6	+	+	+
PHS (Trenton)—PHS (Wilmington)	10	+	+	+
PHS (Trenton)—PHS (Baltimore)	10	−	−	−
PHS (Wilmington)—PHS (Baltimore)	12	−	−	−
PHS (Wilmington)—FDA (Washington)	8	+	+	+
PHS (Baltimore)—PHS (Norfolk)	11	+	+	+
FDA (Washington)—PHS (Norfolk)	11	−	+	+
CU (Buffalo)—PHS (Cleveland)	9	+	+	+
PHS (Cleveland)—PHS (Pittsburgh)	41	−	−	−
PHS (Cleveland)—PHS (Detroit)	11	−	+	+
PHS (Pittsburgh)—PHS (Charleston, W.Va.)	12	−	−	−
PHS (Charlotte)—PHS (Charleston, S.C.)	11	+	+	+
PHS (Atlanta)—CU (Knoxville)	14	−	−	−
FDA (Atlanta)—CU (Knoxville)	5	+	+	0
PHS (Atlanta)—FDA (Atlanta)	11	+	+	+
PHS (Atlanta)—PHS (Montgomery)	13	−	−	−
PHS (New Orleans)—PHS (Columbia)	23	−	−	−
CU (New Orleans)—PHS (New Orleans)	14	+	+	+
PHS (Louisville)—PHS (Indianapolis)	12	−	−	−
PHS (Indianapolis)—PHS (Chicago)	12	+	+	+
CU (Chicago)—PHS (Chicago)	10	−	−	−
PHS (Chicago)—HASL (Chicago)	18	+	+	+
PHS (Memphis)—CU (Little Rock)	10	−	+	+
PHS (Memphis)—PHS (Little Rock)	15	−	−	−
PHS (Chicago)—PHS (Milwaukee)	13	−	−	+
PHS (St. Louis)—CU (St. Louis)	7	−	+	+
PHS (St. Louis)—FDA (St. Louis)	14	−	+	+
CU (Duluth)—PHS (Minneapolis)	6	+	+	+
PHS (Minneapolis)—FDA (Minneapolis)	12	+	+	+
PHS (Des Moines)—PHS (Omaha)	13	+	+	[b] +
CU (Sioux Falls)—PHS (Omaha)	11	+	+	+
PHS (Sioux Falls)—PHS (Omaha)	11	−	+	+
PHS (Wichita)—PHS (Oklahoma City)	12	+	+	+
PHS (Laramie)—PHS (Denver)	15	+	+	+
PHS (Laramie)—FDA (Denver)	5	−	−	0
PHS (Denver)—FDA (Denver)	10	+	+	+
PHS (Idaho Falls)—PHS (Salt Lake City)	17	−	−	−

See footnotes at end of table.

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Table 3. Results of the sign test for paired observations applied to strontium-90 data[a]—Continued

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Seattle)—FDA (Seattle)	11	−	−	−
PHS (Seattle)—CU (Portland, Ore.)	13	+	+	+
PHS (Seattle)—PHS (Portland, Ore.)	17	−	−	−
PHS (Carson City)—CAL (Sacramento)	7	−	−	−
PHS (Carson City)—CAL (Berkeley)	7	−	−	−
CAL (Sacramento)—CAL (Berkeley)	10	+	+	+
PHS (Carson City)—HASL (San Francisco)	6	−	−	−
PHS (San Francisco)—PHS (Carson City)	8	+	+	+
CAL (Sacramento)—HASL (San Francisco)	8	+	+	+
CAL (Sacramento)—FDA (San Francisco)	9	+	+	+
CAL (Berkeley)—HASL (San Francisco)	10	+	+	+
CAL (Berkeley)—FDA (San Francisco)	8	+	+	+
HASL (San Francisco)—FDA (San Francisco)	14	+	+	+
PHS (Los Angeles)—CAL (San Diego)	10	−	−	−
CAL (Los Angeles)—CAL (San Diego)	13	+	+	+
PHS (Los Angeles)—CAL (Santa Barbara)	18	−	−	−
CAL (Los Angeles)—CAL (Santa Barbara)	10	+	+	+
CU (Los Angeles)—PHS (Los Angeles)	8	+	+	+
PHS (Los Angeles)—CAL (Los Angeles)	21	−	−	−
CAL (Needles)—PHS (Phoenix)	17	−	−	−
PHS (Oklahoma City)—FDA (Dallas)	5	+	+	0
FDA (Dallas)—PHS (Austin)	8	+	+	+

[a] + indicates measurements agree at the significance level given. − indicates disagreement. 0 indicates number of data pairs is insufficient to allow application of statistical test.

[b] The Wilcoxon signed-ranks test indicates these data pairs disagree at the 0.05 significance level.

about 75 percent of the comparisons agree where sites are 0–100 miles apart and less than 60 percent agree for cities at 100–200 miles distant. Although the specific location from which the samples for a given geographical area were collected is uncertain, the inference from the results suggest actual differences in the radioactive content of the samples rather than analytical divergences of data. However, whether the results are grouped by agency for separate cities or by city for different agencies, there is little differences in the degree of concordance.

The results of the comparative study are summarized in table 5. The overall agreement (at a significance level equal to 0.05) between the various agencies is about 60 percent for the radionuclides considered in total diet samples collected at about the same place and time. Although the USDA survey (*4*) showed that teenagers have the greatest variety in their diet, our study indicates that the amount of strontium-90 reported in the HASL and CAL general population diets is in agreement with the PHS, FDA, CU, and CONN values in 8 of 16 comparisons.

Conclusions

In consideration of the statistical limitations of the data included in this study and the very low levels of the radioactivities, the values reported by any one of the participating agencies may be accepted with equal reliability.

Four of the six programs reviewed report radioactivity in the diets of children and of teenage groups. Practical consideration of the situation at these low activities indicates there is very little difference between the values reported for diets of these special age groups and those reported for the diet of the general population.

Acknowledgment

The authors gratefully acknowledge the help of Miss Janet Springer in the statistical analysis of the data.

REFERENCES

(*1*) U.S. FOOD AND DRUG ADMINISTRATION. Teen-age diet survey, May 1961–August 1962. Radiol Health Data 4:18–22 (January 1963).

(*2*) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Tri-City diet study. Radiol Health Data 2:181–184 (April 1961).

(*3*) U.S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Institutional Diet Sampling Program. Radiol Health Data 3:42–45 (February 1962).

(*4*) U.S. DEPARTMENT OF AGRICULTURE. Food consumption of households in the United States, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (1955).

(*5*) CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH. Estimated daily intake of radionuclides in California diets, January–June 1964. Radiol Health Data 6:153–154 (March 1965).

Table 4. Results of sign test for paired observations applied to cesium-137 data[a]

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Burlington)—PHS (Portland, Maine)	15	−	+	[b] +
PHS (Burlington)—PHS (Boston)	35	+	+	+
PHS (Burlington)—FDA (Boston)	7	+	+	+
PHS (Burlington)—PHS (Hartford)	9	−	+	+
PHS (Burlington)—CONN (Hartford)	34	+	+	+
PHS (Portland, Maine)—PHS (Boston)	17	+	+	+
PHS (Portland, Maine)—FDA (Boston)	5	−	−	0
PHS (Portland, Maine)—PHS (Hartford)	12	−	−	−
PHS (Portland, Maine)—CONN (Hartford)	16	−	−	[b] +
CU (Portland, Maine)—PHS (Boston)	6	+	+	+
PHS (Boston)—FDA (Boston)	9	+	+	[b] +
PHS (Boston)—PHS (Providence)	5	+	+	0
PHS (Boston)—PHS (Hartford)	12	−	−	−
PHS (Boston)—CONN (Hartford)	48	−	−	[b] +
PHS (Boston)—PHS (New York)	24	−	−	−
PHS (Boston)—HASL (New York)	5	+	+	0
PHS (Boston)—CU (New York)	16	−	−	[b] +
FDA (Boston)—CONN (Hartford)	9	+	+	+
PHS (Providence)—CONN (Hartford)	5	+	+	0
PHS (Hartford)—CONN (Hartford)	12	+	+	+
PHS (Hartford)—PHS (New York)	5	−	−	0
PHS (Hartford)—PHS (Trenton)	9	−	+	[b] +
CONN (Hartford)—PHS (New York)	14	−	+	[b] +
CONN (Hartford)—CU (New York)	8	+	+	+
CONN (Hartford)—PHS (Trenton)	11	−	−	−
PHS (New York)—CU (New York)	11	+	+	+
PHS (New York)—PHS (Trenton)	6	−	+	+
PHS (New York)—PHS (Wilmington)	8	+	+	+
PHS (New York)—PHS (Baltimore)	6	−	−	−
PHS (Trenton)—PHS (Wilmington)	9	−	+	[b] +
PHS (Trenton)—PHS (Baltimore)	9	−	+	+
PHS (Wilmington)—PHS (Baltimore)	13	−	−	−
PHS (Wilmington)—FDA (Washington)	5	+	+	0
PHS (Baltimore)—PHS (Norfolk)	13	+	+	+
FDA (Washington)—PHS (Norfolk)	12	−	−	−
CU (Buffalo)—PHS (Cleveland)	10	+	+	+
PHS (Cleveland)—PHS (Detroit)	11	+	+	+
PHS (Cleveland)—PHS (Pittsburgh)	37	+	+	+
PHS (Pittsburgh)—PHS (Charleston, W.Va.)	11	−	−	−
PHS (Milwaukee)—PHS (Chicago)	9	+	+	+
PHS (Chicago)—HASL (Chicago)	5	+	+	0
PHS (Chicago)—CU (Chicago)	10	+	+	+
PHS (Chicago)—PHS (Indianapolis)	13	−	−	−
PHS (Indianapolis)—PHS (Louisville)	13	−	−	−
PHS (Charlotte)—PHS (Charleston, S.C.)	12	−	−	−
CU (Knoxville)—PHS (Atlanta)	15	−	+	+
CU (Knoxville)—FDA (Atlanta)	6	+	+	+
PHS (Atlanta)—FDA (Atlanta)	12	+	+	+
PHS (Atlanta)—PHS (Montgomery)	12	−	−	−
PHS (Columbia)—PHS (New Orleans)	21	−	−	[b] +
PHS (New Orleans)—CU (New Orleans	15	+	+	+
PHS (Little Rock)—PHS (Memphis)	14	−	−	[b] +
CU (Little Rock)—PHS (Memphis)	10	−	−	−
PHS (St. Louis)—FDA (St. Louis)	9	+	+	+
PHS (St. Louis)—CU (St. Louis)	6	+	+	+
PHS (Des Moines)—PHS (Omaha)	12	+	+	+
PHS (Omaha)—PHS (Sioux Falls)	12	+	+	[b] +
PHS (Omaha)—CU (Sioux Falls)	10	−	+	+
PHS (Minneapolis)—FDA (Minneapolis)	12	+	+	+
PHS (Minneapolis)—CU (Duluth)	9	−	+	+
PHS (Wichita)—PHS (Oklahoma City)	11	+	+	+
PHS (Oklahoma City)—FDA (Dallas)	5	+	+	0
FDA (Dallas)—PHS (Austin)	9	−	+	+
PHS (Laramie)—PHS (Denver)	14	−	−	+
PHS (Laramie)—FDA (Denver)	5	+	+	0
PHS (Denver)—FDA (Denver)	10	+	+	+
PHS (Idaho Falls)—PHS (Salt Lake City)	17	−	−	−
CU (Salt Lake City)—PHS (Salt Lake City)	6	+	+	+
PHS (Seattle)—FDA (Seattle)	10	+	+	+
PHS (Seattle)—PHS (Portland, Ore.)	17	−	−	−

See footnotes at end of table.

Table 4. Results of sign test for paired observations applied to cesium-137 data[a]—Continued

Comparison	Number of data pairs	0.25 significance level	0.10 significance level	0.05 significance level
PHS (Seattle)—CU (Portland, Ore.)	14	−	+	+
PHS (Carson City)—CAL (Sacramento)	7	−	−	−
PHS (Carson City)—CAL (Berkeley)	7	−	−	−
PHS (Carson City)—PHS (San Francisco)	7	−	+	+
CAL (Sacramento)—CAL (Berkeley)	21	+	+	+
CAL (Sacramento)—FDA (San Francisco)	7	−	+	[b] +
CAL (Berkeley)—FDA (San Francisco)	6	−	−	−
FDA (San Francisco)—HASL (San Francisco)	5	−	−	0
CAL (Santa Barbara)—PHS (Los Angeles)	15	−	+	+
CAL (Santa Barbara)—CAL (Los Angeles)	16	+	+	+
PHS (Los Angeles)—CU (Los Angeles)	11	+	+	+
PHS (Los Angeles)—CAL (Los Angeles)	19	−	−	[b] +
PHS (Los Angeles)—CAL (San Diego)	19	−	−	−
CAL (Los Angeles)—CAL (San Diego)	20	+	+	+
CAL (Needles)—PHS (Phoenix)	17	−	−	−

[a] + indicates measurements agree at the significance level given. − indicates disagreement. 0 indicates number of data pairs is insufficient to allow application of statistical test.

[b] The Wilcoxon signed-ranks test indicates these data pairs disagree at the 0.05 significance level.

Table 5. Summary of results of statistical tests shown in tables 3 and 4[a]

	Sign test			Signed-ranks test
	$\alpha = 0.25$	$\alpha = 0.10$	$\alpha = 0.05$	$\alpha = 0.05$
Strontium-90 data:				
Total number of sets of data pairs	92	92	82	82
Number of cases where test indicates data do not differ, on the average	47 (51%)	57 (62%)	54 (66%)	51 (62%)
Cesium-137 data:				
Total number of sets of data pairs	85	85	75	75
Number of cases where test indicates data do not differ, on the average	40 (47%)	55 (65%)	55 (73%)	42 (56%)

[a] α = significance level of test.

REFERENCES—Continued

(6) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

(7) CONSUMERS' UNION. Selected results from total diet studies, May 1961–June 1962. Radiol Health Data 4:353–358 (July 1963).

(8) U.S. FOOD AND DRUG ADMINISTRATION. Radionuclides in diets for teen-agers. Radiol Health Data 4:285–286 (June 1963); 5:181–183 (April 1964); 6:378–380 (July 1965); 7:459–461 (August 1966).

(9) U.S. ATOMIC ENERGY COMMISSION. Health and Safety Laboratory Manual of Standard Procedures, AEC Report NYO–4700:E–38–01. New York Operations Office (1957).

(10) U.S. PUBLIC HEALTH SERVICE, DIVISION OF RADIOLOGICAL HEALTH. Radionuclides in institutional diet samples. Radiol Health Data 3:224–242 (July 1962); 3:471–476 (December 1962); 4:177–182 (April 1963); 4:347–352 (July 1963); 4:441–446 (September 1963); 4:605–610 (December 1963); 5:131–136 (March 1964); 5:329–334 (July 1964); 5:485–491 (October 1964); 6:31–36 (January 1965); 6:216–222 (April 1965); 6:371–377 (July 1965); 6:548–554 (October 1965); 7:92–98 (February 1966); 7:288–292 (May 1966); 7:398–403 (July 1966); 7:580–583 (October 1966); 8:15–18 (January 1967); 8:209–212 (April 1967); 8:388–391 (July 1967); 8:591–596 (October 1967); 9:34–36 (January 1968); 9:217–220 (April 1968); and 9:359–363 (July 1968).

(11) BARATTA, E. J. and E. R. WILLIAMS. Radionuclide levels in teen-age diets—a comparative study of two sampling programs, February–June 1964. Radiol Health Data 6:37–40 (January 1965).

(12) CONSUMERS' UNION. Selected results from total diet studies, February 1963–June 1964. Radiol Health Data 6:700–703 (December 1965).

(13) U.S. ATOMIC ENERGY COMMISSION, HEALTH AND SAFETY LABORATORY. Tri-City diet study. Radiol Health Data 2:435–436 (October 1961); 2:519 (December 1961); 3:82–83 (March 1962); 3:183–185 (June 1962); 3:334–335 (September 1962); 4:13–14 (January 1963); 4:130–131 (March 1963); 4:289–290 (June 1963); 4:446–448 (September 1963); 4:611–612 (December 1963); 5:137–138 (March 1964); 5:285–288 (June 1964); 5:288–290 (June 1964); 5:433–434 (September 1964); 5:434–436 (September 1964); 5:603–604 (December 1964); 6:151–152 (March 1965); 6:323–324 (June 1965); 6:503–506 (September 1965); 6:704–705 (December 1965); 7:170–171 (March 1966); 7:349–350 (June 1966); 7:506–507 (September 1966); 7:713–714 (December 1966); 8:154–157 (March 1967); 8:329–330 (June 1967); 8:517–518 (September 1967); 9:166–167 (March 1968); 9:302–304 (June 1968).

(14) CALIFORNIA STATE DEPARTMENT OF PUBLIC HEALTH. Estimated daily intake of radionuclides in California diets. Radiol Health Data 6:501–502 (September 1965); 7:172–173 (March 1966); 7:351–352 (June 1966); 7:508–511 (September 1966); 8:19–21 (January 1967); 8:271–274 (May 1967); 8:596–599 (October 1967); 9:102–104 (February 1968); 9:261–263 (May 1968).

(15) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet. Radiol Health Data Rep 7:99 (February 1966); 7:645–646 (November 1966); 8:274–275 (May 1967); 8:646–647 (November 1967); 9:264 (May 1968).

(16) NATRELLA, M. G. Experimental statistics, NBS Handbook 91. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (August 1963).

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Technical Notes

Environmental Levels of Radioactivity in Utah Following Operation Pinstripe[1]

R. C. Pendleton and *R. D. Lloyd*[2]

Following the announcement by the U.S. Atomic Energy Commission that the underground nuclear detonation of April 25, 1966, had vented (external gamma) radioactivity surveillance was carried out and a series of samples of green vegetation were collected on April 29 and 30, 1966. The green samples were chosen because they would not contain much residual radioactivity from previous shots since the growing time, at the most, for these specimens was 2 weeks. This surveillance and sampling was designed to show the location in our sampling network where fresh fission elements from this venting had fallen.

The samples were counted 3 days after collection using an 8- by 4-inch NaI (T1) crystal and a 400-channel pulse-height analyser. The concentrations of the various gamma-ray emitting radionuclides present in these samples were calculated by the IBM 7044 computer at the University of Utah Computer Center using the Polyspec program (*1*). Increased levels of iodine-131 and zirconium-95 were detected in all of the samples collected at that time. Figure 1 shows the gamma-ray spectrum of one of these samples, and table 1 lists the concentrations of radionuclides in several samples.

After a delay of more than 2 months when the iodine-131 activity had virtually disappeared because of radioactive decay, the samples were recounted. After an additional delay of more than 4 months (>6 months total) when any ruthenium-103 originally present would have decayed to less than 4 percent of the initial activity, the samples were again recounted.

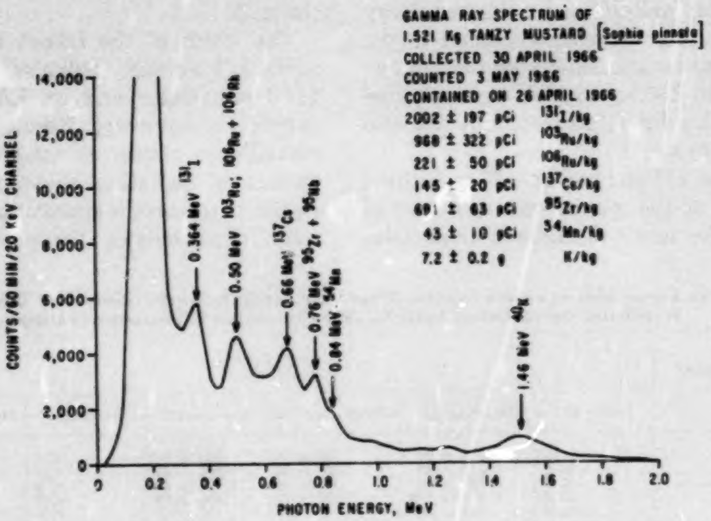

Figure 1. Spectrum of radionuclides in an annual spring plant

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[2] University of Utah, Salt Lake City, Utah.

Table 1. Radionuclides in early spring vegetation collected following Operation Pinstripe

Station and sample number	Date (1966)	Concentration[a] (pCi/kg)						Potassium[b] (g/kg)
		Iodine–131	Ruthenium–103	Ruthenium–106	Cesium–137	Zirconium–95	Manganese–54	
40–139[c]	4/29	530 ± 45	257 ± 86	ND	340 ± 30	88 ± 21	ND	6.6 ± 0.4
41–132	4/29	883 ± 85	382 ± 107	177 ± 50	118 ± 10	268 ± 21	ND	9.4 ± .2
50–98[c]	4/30	1,107 ± 113	340 ± 96	407 ± 80	199 ± 40	291 ± 31	110 ± 20	9.6 ± .4
50–99[c]	4/30	2,002 ± 197	968 ± 322	221 ± 50	145 ± 20	691 ± 63	43 ± 10	7.2 ± .2
50–100[c d]	4/30	690 ± 70	282 ± 86	249 ± 50	213 ± 16	132 ± 16	56 ± 15	8.6 ± .3

[a] Standard errors represent counting statistics only. Antimony–125 in all samples was below limit of detection.
[b] Potassium determined by the analysis for potassium–40.
[c] Tansymustard (*Sophia pinnata*).
[d] Kentucky bluegrass (*Poa prapensis*).
ND, nondetectable.

Since 40-day, half-life ruthenium–103 exhibits a gamma-ray peak at about 0.5 MeV and 365-day, half-life ruthenium–106 also has a 0.5 MeV gamma-ray associated with its decay chain, identification of both of these isotopes in a sample by recording a single spectrum is difficult. However, if two or more spectra are recorded sufficiently separated in time so that the ruthenium–103 undergoes considerable radioactive decay, appropriate analysis can separate the relative contribution of each to the observed 0.5 MeV peak.

The amount of ruthenium–106 in each sample at the 6-month count was corrected for radioactive decay back to each of the other counting dates. The counting rate corresponding to these values was then subtracted from the totals. The residual peak at 0.5 MeV was due to ruthenium–103. The ruthenium–103 activities could then be calculated based on its 40-day half-life and published decay scheme (*2*). Counting efficiencies (counts in the photopeak) per emitted gamma-ray for ruthenium–103 and ruthenium–106 at 0.5 MeV were assumed to be identical. This analytical technique was also reported in reference 3.

Although iodine–131 and cesium–137 make up a large percentage of the gamma-ray spectrum of these samples, the levels of these radionuclides normalized relative to the other fission products present do not show isotopic fractionation in favor of elements having gaseous precursors as advanced by Martell relative to underground nuclear detonations (*4*).

In contrast to the obviously fresh fission spectrum found in the samples taken April 30 in the main fallout track, samples of desert shrubs taken on April 23 showed a spectrum characteristic of old fallout (table 2). These levels reflect several years of contamination accumulation.

No significant increases in iodine–131, cesium–137 or strontium–90 were detected in milk as a result of this venting. Because the dairy cattle in the selected sampling array that were within the reported fallout tract were not grazing during this period of time, only small quantities of fresh fission products would be expected to appear in the milk.

The width of the fallout track was surveyed using a Precision Radiation Instrument Model 111B scintillator and an Eberline E–510 beta-gamma survey meter. Results of our background surveillance appear in table 3. Only slight elevations of radiation above normal background (which in this area is approximately 0.02 mR/hour) were found outside the probable fallout path,

Table 2. Levels of radionuclides in desert shrubs (Shadscale, *Atriplex confertifolia* and Greasewood, *Sarcobatus vermiculatus*) collected April 23, 1966 (just prior to Pinstripe venting)

Station and sample number	Concentration[a] (pCi/kg)						Potassium[b] (g/kg)
	Iodine–131	Antimony–125	Ruthenium–106	Cesium–137	Zirconium–95	Manganese–54	
211–1–2	<32	336 ± 50	156 ± 50	461 ± 40	<14	89 ± 20	8.3 ± 0.2
211–1–3	<29	221 ± 50	222 ± 50	326 ± 30	<13	96 ± 20	12.6 ± .2
211–1–6	<18	823 ± 80	391 ± 40	1,193 ± 60	< 9	213 ± 20	7.4 ± .2
211–1–7	<34	1,034 ± 100	732 ± 70	1,426 ± 70	<17	335 ± 30	10.4 ± .2
211–1–9	<38	151 ± 30	ND	131 ± 13	<19	ND	7.1 ± .1

[a] Standard errors represent counting statistics only.
[b] Potassium determined by the analysis for potassium–40.
ND, nondetectable.

Table 3. Background radiation levels following Operation Pinstripe

Sampling location	Radiation level[a] (mR/hr)
Station 34, Chester, Sanpete Country	[b]0.029 ± .0058 [c].035 ± .0035
Station 33, Ephraim, Sanpete County	.030 ± .0042 .042 ± .0030
Manti, Sanpete County	.024 ± .0029 .026 ± .0020
Gunnison, Sanpete County	.029 ± .0033 .033 ± .0034
Station 66, Axtell, Sevier County	.030 ± .0042 .036 ± .0020
Salina, Sevier County	.019 ± .0024 .024 ± .0010
Richfield, Sevier County	.021 ± .0033 .022 ± .0037
Station 40, Monroe, Sevier County	.028 ± .0034 .045 ± .0065
Summit between Cove Fort and Monroe, Millard County	.038 ± .0051 .036 ± .0043
Station 41, Beaver, Beaver County	.026 ± .0020 .039 ± .0029
Station 50, Beaver, Beaver Country	.050 ± .0052 .056 ± .0062
Station 43, Parowan, Iron County	.022 ± .0034 .033 ± .0020
Cedar City (City Park), Iron County	.028 ± .0025 .028 ± .0020
Kanarraville, Iron County	.022 ± .0075 .044 ± .0058
Station 46, Midvalley Road, 4 miles NW of Cedar City, Iron County	.027 ± .0012 .032 ± .0046
Minersville, Beaver County	.028 ± .0020 .035 ± .0042
Milford, Beaver County	.027 ± .0060 .053 ± .0044
Ranch Exit, Interstate 15, Beaver County	.030 ± .0064 .053 ± .0044
Cove Fort, Millard County	.038 ± .0046 .040 ± .0027
Station 54, Ferron, Emery County	.025 ± .0022 .042 ± .0066
Summit between Willow Creek, Carbon County and Indian Canyon, Duchesne County	.035 ± .0034 .046 ± .0036
Station 64, Wellington, Carbon County	.024 ± .0010 .032 ± .0041
Price, Carbon County	.031 ± .0037 .035 ± .0045
Bamberger Monument, Monument Park, Carbon County	.026 ± .0033 .052 ± .0034
Indian Canyon (5 miles NE of summit) Duchesne County	.030 ± .0035 .052 ± .0098
Current Creek Lodge, Wasatch County	.024 ± .0019 .032 ± .0020
Station 58, Duchesne County	[d].020 .022

[a] Each measurement represents the mean of 5 or more readings at 15 seconds intervals, ± values are standard errors.
[b] One meter above ground surface—gamma radiation readings only.
[c] Ground surface beta plus gamma radiation readings.
[d] Standard error not available.

which centered around stations 40, 41, and 50 (figure 2). However, elevation of the radioactivity level above background by a factor of 2 was noted at several locations. Had the surveillance extended into northern Utah, elevated levels above background would probably have been detected in stations 1, 2, 3, 4, and 5 in the Salt Lake Valley and stations in Summit County 9, 10, 31, and 32—10.3 pCi gross beta radioactivity per cubic meter[3] of air was reported at Provo on April 26, 1966 by the Utah State Radiological Surveillance Network, (*5*). Our surveillance was conducted primarily in the south and east section of our sampling array because first reports of increased airborne radioactivity, released by the Utah State Department of Health, showed an elevation (16.2 pCi/m^3) only at Richfield, which is within 10 miles of our station No. 40. However, our measurements indicated that the levels of radiation at Richfield were not above normal background radiation.

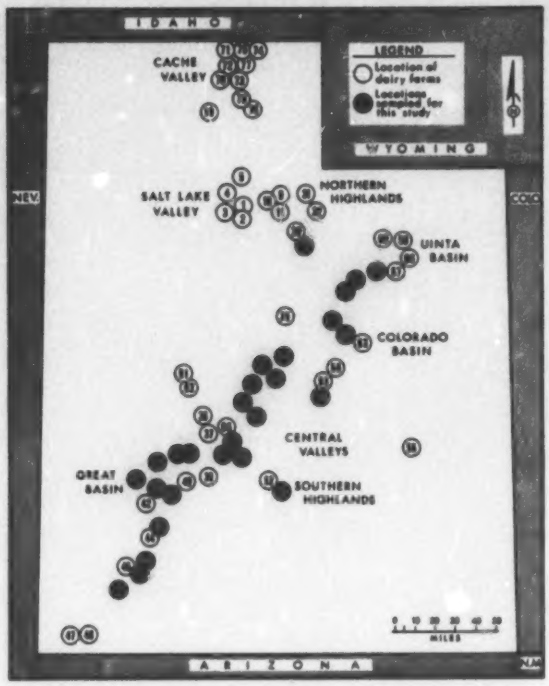

Figure 2. Sampling locations of diary farms

REFERENCES

(*1*) LLOYD, R. D., J. A. CHRISTENSEN, B. W. CHURCH, P. S. FISHER, C. W. MAYS, and R. C. PENDLETON. Polyspec: a computer program to resolve complex gamma-ray spectra from samples of different densities. Health Physics 13:851–855 (1967).

(*2*) STROMINGER, D., J. HOLLANDER, and G. T. SEABORG. Table of Isotopes. Rev Mod Physics 30:358 (1958).

(*3*) CHURCH, B. W., R. D. LLOYD, R. C. PENDLETON, and C. W. MAYS. Evidence for radio-ruthenium in milk. Nature 207:775 (1965).

(*4*) MARTELL, E. A. Iodine-131 fallout from underground tests. Science 143:126–129 (1964).

(*5*) DALLEY, D. R. Monthly Radiological Surveillance Reports—January 1966 to September 1966. Utah State Department of Health, Division of Sanitation (1966).

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[3] The average gross beta radioactivity for Provo for the period, March 1–April 25, was 0.6 pCi/m^3 with a maximum of 2.8 pCi/m^3 occurring on March 21.

Data

SECTION I. MILK AND FOOD

Milk Surveillance, October 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network, (PMN) sponsored by the Bureau of Radiological Health, and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*: Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations
Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by these several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk. The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and radiocesium, respectively). The contents of both calcium and potassium in milk have been measured

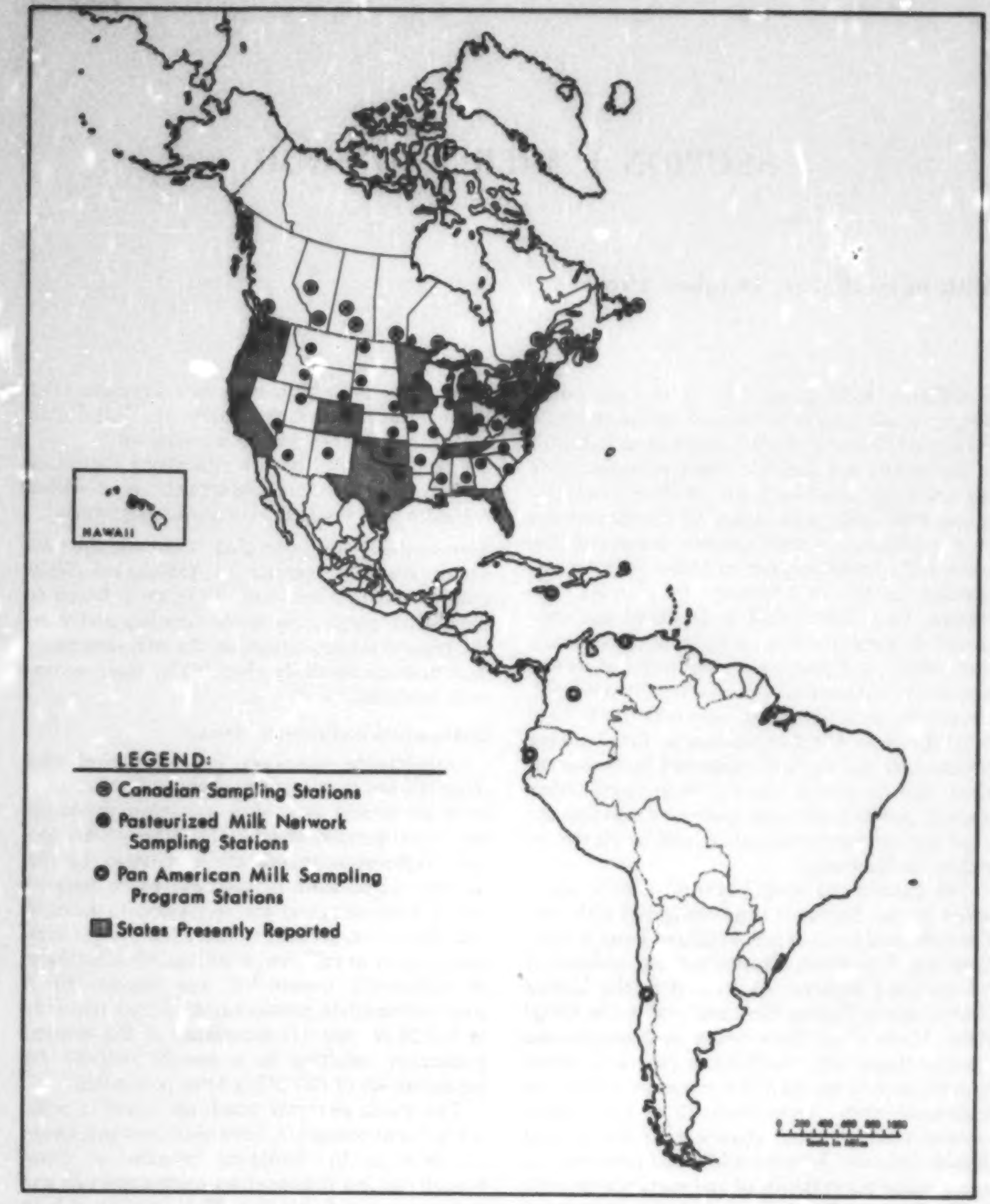
HAWAII
LEGEND:
⊗ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
⊙ Pan American Milk Sampling Program Stations
▨ States Presently Reported

Figure 1. Milk sampling networks in the Western Hemisphere

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extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium-90, iodine-131, cesium-137 and barium-140. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 15 participated in the experiment.

The iodine-131 and cesium-137 results show much improvement over previous tests. Barium-140 results also look good which is encouraging, since this is the first time barium-140 was analyzed for this type of experiment. However, strontium-89 and strontium-90 analysis still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium-40, iodine-131, cesium-137, and barium-140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collect and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium-90 and cesium-137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine-131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of this radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environment conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guides (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/yr)	RPG (rad/yr)	Guidance for suitable samples of exposed population group[a]			
				Corresponding continuous daily intake (pCi/day)	Range I[b] (pCi/day)	Range II[b] (pCi/day)	Range III[b] (pCi/day)
Strontium-89	Bone	[c] 1.5	0.5	[d] 2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c] .5	.17				
Strontium-90	Bone	[c] 1.5	.5	[d] 200	0-20	20-200	200-2,000
	Bone marrow	[c] .5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,600	0-360	360-3,600	3,600-36,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/yr to the bone is estimated to result in a dose of 0.5 rad/yr to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guides (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c] 1,110,000
Strontium-90	Bone marrow			[c] 51,000
Cesium-137	Whole body			[c] 720,000
Iodine-131	Thyroid	30	10	[d] 70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

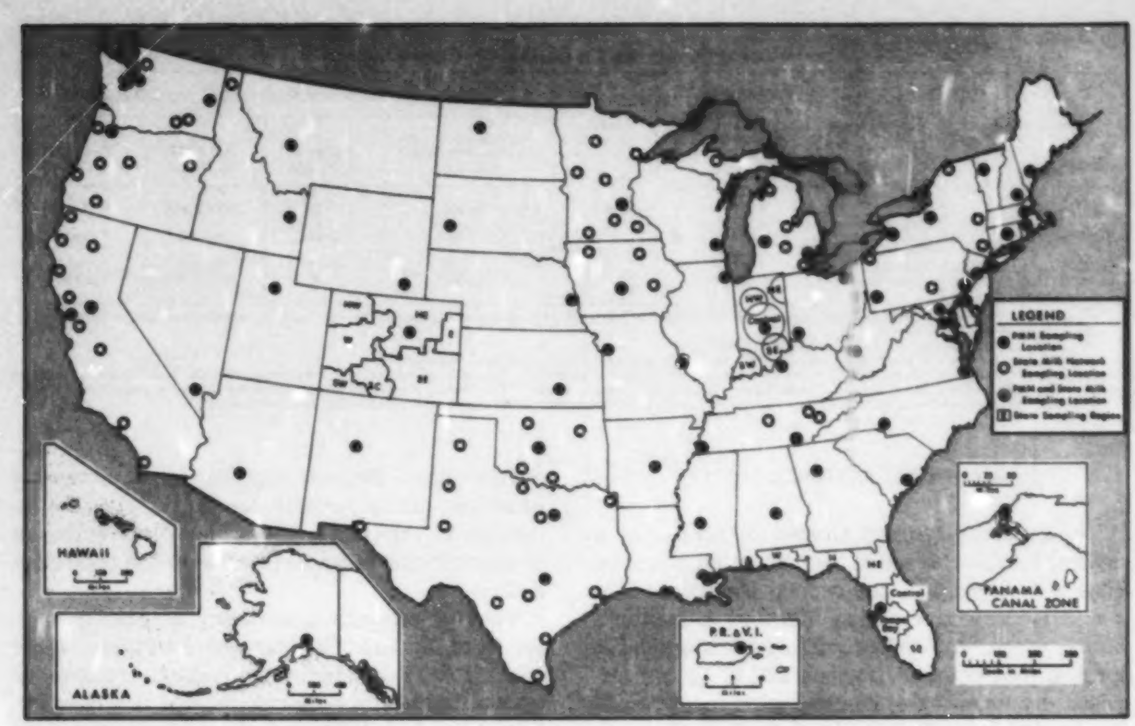

Figure 2. State and PMN milk sampling locations in the United States

and the pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium-90, iodine-131 and cesium-137 for October 1969 and the 12-month period, November

Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	11	7	0(5)	0	10(5)	10
Alaska:	Palmer[c]	P	4	6	0(4)	0	0(4)	6
Ariz:	Phoenix[c]	P	0	1	0(5)	0	0(5)	0
Ark:	Little Rock[c]	P	12	18	0(4)	0	16(4)	17
Calif:	Sacramento[c]	P	0	1	0(5)	0	0(5)	0
	San Francisco[c]	P	0	2	0(5)	0	0(5)	0
	Del Norte	P	22	19	0(4)	0	14(4)	14
	Fresno	P	0	0	0	0	0	1
	Humboldt	P	3	5	0(6)	0	0(6)	6
	Los Angeles	P	0	0	0	0	0	0
	Mendocino	P	4	3	0	0	0	1
	Sacramento	P	0	2	0	0	0	1
	San Diego	P	0	0	0	0	0	1
	Santa Clara	P	0	0	0	0	0	2
	Shasta	P	3	3	0	0	0	3
	Sonoma	P	0	2	0	0	0	0
Colo:	Denver[c]	P	5	5	0(5)	0	5(5)	2
	West	R	(4)		(e)	(e)	(e)	(e)
	Northeast	R	(4)		(e) (3)	(e)	(e) (3)	(e)
	East	R	(4)		NS	(e)	NS	(e)
	Southeast	R	(4)		(e)	(e)	(e)	(e)
	South central	R	(4)		NS	(e)	NS	(e)
	Southwest	R	(4)		(e) (2)	(e)	(e) (2)	(e)
	Northwest	R	(4)		(e)	(e)	(e)	(e)
Conn:	Hartford[c]	P	6	8	0(5)	0	9(5)	12
	Central	P	6	7	0(5)	0	12(5)	11
Del:	Wilmington[c]	P	9	9	0(5)	0	3(5)	7
D.C.:	Washington[c]	P	7	8	0(5)	0	3(5)	4
Fla:	Tampa[c]	P	5	7	0(5)	0	55(5)	56
	West	R	14	11	0	0	52	25
	North	R	18	14	0	0	26	30
	Northeast	R	5	8	0	0	73	65
	Central	R	7	7	0	1	72	56
	Tampa Bay area	R	9	8	0	0	70	62
	Southeast	R	6	8	0	0	93	93
Ga:	Atlanta[c]	P	11	10	0(5)	0	20(5)	19
Hawaii:	Honolulu[c]	P	2(4)	3	0(4)	0	0(4)	0
Idaho:	Idaho Falls[c]	P	5	5	0(4)	0	0(4)	6
Ill:	Chicago[c]	P	9	8	0(4)	0	8(4)	10
Ind:	Indianapolis[c]	P	6	8	0(4)	0	2(4)	6
	Northeast	P	8	12	0	0	10	10
	Southeast	P	10	8	0	0	10	10
	Central	P	8	10	0	0	10	10
	Southwest	P	8	10	0	0	20	10
	Northwest	P	10	10	0	0	20	20
Iowa:	Des Moines[c]	P	5	5	0(5)	0	0(5)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Charles City	P	NS		NS		NS	
Kans:	Wichita[c]	P	6	7	0(4)	0	3(4)	2
Ky:	Louisville[c]	P	10	9	0(4)	0	2(4)	5
La:	New Orleans[c]	P	14	17	0(5)	0	19(5)	19
Maine:	Portland[c]	P	9	12	0(5)	1	16(5)	24
Md:	Baltimore[c]	P	11	9	0(4)	0	6(4)	7
Mass:	Boston[c]	P	11	11	0(4)	0	21(4)	21
Mich:	Detroit[c]	P	6	8	0(4)	0	10(4)	9
	Grand Rapids	P	6	10	0(4)	4	13(4)	14
	Bay City	P	7	7	(e) (3)	(e)	7	10
	Charlevoix	P	8	9	(e) (4)	(e)	15	16
	Detroit	P	7	5	(e) (4)	(e)	6	6
	Grand Rapids	P	6	8	(e) (4)	(e)	6	11
	Lansing	P	6	6	(e) (2)	(e)	14	10
	Marquette	P	9	10	(e) (2)	(e)	19	28
	Monroe	P	6	4	(e) (2)	(e)	0	1
	South Haven	P	NS	7	NS	(e)	NS	8
Minn:	Minneapolis[c]	P	12	10	0(4)	0	2(4)	11
	Bemidji	P	21	17	0	0	36	25
	Mankato	P	9	8	0	0	12	0
	Rochester	P	9	9	0	0	0	0
	Duluth	P	18	19	0	0	24	25
	Worthington	P	7	8	0	0	0	0
	Minneapolis	P	14	12	0	0	11	0
	Fergus Falls	P	13	9	0	0	14	0
	Little Falls	P	8	10	0	0	0	12
Miss:	Jackson[c]	P	11	13	0(4)	0	6(4)	15
Mo:	Kansas City[c]	P	7	7	0(5)	0	1(5)	1
	St. Louis[c]	P	7	8	0(5)	0	0(5)	2
Mont:	Helena[c]	P	NA	5	0(3)	0	12(3)	6
Nebr:	Omaha[c]	P	6	6	0(4)	0	5(4)	2
Nev:	Las Vegas[c]	P	0	1	0(4)	0	0(4)	0
N.H.:	Manchester[c]	P	11	9	0(4)	0	16(4)	21
N.J.:	Trenton[c]	P	9	9	0(4)	0	4(4)	8
N.Mex:	Albuquerque[c]	P	2	2	0(4)	0	0(4)	1

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued								
N.Y.:	Buffalo[c]	P	7	7	0(5)	0	2(5)	9
	New York City[c]	P	8	10	0(4)	0	9(4)	13
	Syracuse[c]	P	7	8	0(4)	0	5(4)	9
	Albany	P	(e)	(e)	0(4)	0	(e) (4)	(e)
	Buffalo	P	(e)	3	0	0	(e)	(e)
	Massena	P	4	9	0(2)	0	(e) (2)	(e)
	Newburg	P	10	11	0	0	(e)	(e)
	New York City	P	9	10	0	0	(e) (4)	(e)
	Syracuse	P	(e)	7	0	0	(e)	(e)
N.C.:	Charlotte[c]	P	13	14	0(4)	0	8(4)	12
N.Dak:	Minot[c]	P	10	10	0(4)	0	17(4)	13
Ohio:	Cincinnati[c]	P	7	9	0(5)	0	2(5)	3
	Cleveland[c]	P	8	9	0(5)	0	3(5)	7
Okla:	Oklahoma City[c]	P	8	8	0(4)	0	7(4)	10
	Oklahoma City	P	NS		NS		NS	
	Enid	P	NS		NS		NS	
	Tulsa	P	NS		NS		NS	
	Lawton	P	NS		NS		NS	
	Ardmore	P	NS		NS		NS	
Ore:	Portland[c]	P	4	7	0(5)	0	0(5)	7
	Baker	P	NA	2	(e)	(e)	(e)	(e)
	Coos Bay	P	NA	6	(e)	(e)	21	11
	Eugene	P	NA	4	(e)	(e)	(e)	8
	Medford	P	NA	2	(e)	(e)	35	17
	Portland composite	P	NA	3	(e)	(e)	3(5)	6
	Portland local	P	NA	4	(e)	(e)	15(5)	10
	Redmond	P	NA	2	(e)	(e)	(e)	5
	Tillamook	P	NA	5	(e)	(e)	NA	21
Pa:	Philadelphia[c]	P	11	9	0(5)	0	3(5)	5
	Pittsburgh[c]	P	11	12	0(4)	0	3(4)	8
	Dauphin	P	NA	7	0	2	25	15
	Erie	P	15	11	13	5	22	18
	Philadelphia	P	6	9	4	0	17	13
	Pittsburgh	P	13	11	11	1	26	18
R.I.:	Providence[c]	P	5	9	0(4)	0	15(4)	17
S.C.:	Charleston[c]	P	10	11	0(4)	0	24(4)	23
S.Dak:	Rapid City[c]	P	6	7	0(4)	0	0(4)	6
Tenn:	Chattanooga[c]	P	9	11	0(4)	0	11(4)	13
	Memphis[c]	P	8	9	0(5)	0	0(5)	6
	Chattanooga	P	11	13	4(4)	0	19(4)	16
	Clinton	P	NS	16	NS	1	NS	15
	Knoxville	P	11	10	0(2)	0	0(2)	8
	Nashville	P	9	9	8(2)	0	7(2)	5
Tex:	Austin[c]	P	2	2	0(4)	0	4(4)	4
	Dallas[c]	P	7	6	0(4)	0	3(4)	6
	Amarillo	R	NS	4	NS	0	NS	0
	Corpus Christi	R	NS	4	NS	0	NS	0
	El Paso	R	NS	2	NS	0	NS	0
	Fort Worth	R	3	3	0	0	0	20
	Harlingen	R	NS	2	NS	0	NS	0
	Houston	R	5	6	0	0	10	11
	Lubbock	R	NS	3	NS	0	NS	0
	Midland	R	3	2	0	0	0	0
	San Antonio	R	NS	3	NS	0	NS	0
	Texarkana	R	NS	12	NS	0	NS	10
	Uvalde	R	NS	1	NS	0	NS	0
	Wichita Falls	R	NS	6	NS	0	NS	0
Utah:	Salt Lake City[c]	P	9	4	0(4)	0	0(4)	6
Vt:	Burlington[c]	P	8	8	0(4)	0	18(4)	14
Va:	Norfolk[c]	P	12	10	0(5)	0	6(5)	7
Wash:	Seattle[c]	P	5	7	0(5)	0	11(5)	14
	Spokane[c]	P	8	7	0(4)	0	2(4)	5
	Benton County	R	NS	1	NS	0	NS	3
	Franklin County	R	3	2	0	0	0	0
	Sandpoint, Idaho	R	11	11	0	0	28	28
	Skagit County	R	5	7	0	0	16	14
W.Va:	Charleston[c]	P	10	9	0(5)	0	2(5)	7
Wisc:	Milwaukee[c]	P	6	7	0(5)	0	7(5)	11
Wyo:	Laramie[c]	P	6	5	0(5)	0	2(5)	9
CANADA:								
Alberta:	Calgary	P	9	8	(d)		13	15
	Edmonton	P	8	7	(d)		11	14
British Columbia:	Vancouver	P	11	12	(d)		34	35
Manitoba:	Winnipeg	P	8	8	(d)		25	25
New Brunswick	Fredericton	P	15	13	(d)		14	18
Newfoundland:	St. Johns	P	13	17	(d)		34	36
Nova Scotia:	Halifax	P	9	10	(d)		18	20
Ontario:	Ft. William	P	13	16	(d)		33	31
	Ottawa	P	8	9	(d)		14	16

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for October 1969 and 12-month period, November 1968 through October 1969—Continued

Sampling location		Type of sample [a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average [b]	12-month average	Monthly average [b]	12-month average	Monthly average [b]	12-month average
CANADA: (Continued)								
Ontario:	Sault Ste. Marie	P	9	13	([d])		24	30
	Toronto	P	5	5	([d])		15	12
	Windsor	P	5	6	([d])		12	12
Quebec:	Montreal	P	7	9	([d])		15	18
	Quebec	P	12	11	([d])		26	27
Saskatchewan:	Regina	P	8	7	([d])		14	13
	Saskatoon	P	13	8	([d])		10	12
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	1	1	0	0	0	1
Chile:	Santiago	P	0	0	0	0	0	1
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamacia:	Kingston	P	3	5	0	0	35	95
Venezuela:	Caracas	P	2	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	1	0(4)	0	13(4)	12
Puerto Rico:	San Juan[c]	P	3	4	0(4)	0	3(4)	7
PMN network average[f]			7	8	0	0	7	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or National network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote[c].
NA, no analysis.
NS, no sample collected.

1968 to October 1969. Except where noted the monthly average represents a single sample for the sampling station. Barium-140 levels for all stations were nondetectable during this period. The following station averages reflect samples in which strontium-89 was detected: Kans., Wichita (PMN) 6 pCi/liter; Mo., St. Louis, (PMN) 7 pCi/liter; N. Dak., Minot (PMN) 11 pCi/liter; and S. Dak., Rapid City (PMN) 6 pCi/liter.

Iodine-131 results are included in the table even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting levels for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 22 pCi/liter in the United States for the month of October 1969 and the highest 12-month average was 19 pCi/liter (Del Norte, Calif., and Duluth, Minn.), representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 93 pCi/liter in the United States for the month of October 1969 and the highest 12-month average was 93 pCi/liter (Southeast Florida), representing 2.6 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below the practical reporting level, with the following exceptions: Pa. (State) Erie, 13 pCi/liter; Philadelphia, 4 pCi/liter; Pittsburgh, 11 pCi/liter; Tenn. (State) Chattanooga, 4 pCi/liter; Nashville, 8 pCi/liter.

Acknowledgement

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Bureau of Radiological Health
Division of Environmental Sanitation
California State Department of Health

Radiological Health Section
Division of Air, Occupational and Radiation Hygiene
Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(*1*) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1957 through April 1958. Amer J Public Health 49:225 (February 1959).

(*2*) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(*3*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730-746 (December 1968).

(*4*) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(*5*) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium-140, strontium-89, and strontium-90 measurements in milk, July-December 1969. Technical experiment 69-MKAQ-2, Analytical Quality Control Service, Bureau of Radiological Health (October 1969).

(*6*) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621-627 (November 1967).

(*7*) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475-488 (September 1968).

(*8*) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(*9*) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(*10*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(*11*) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superindent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(*12*) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida, Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25-29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95-101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those listed below. These networks provide data useful for developing estimates of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967-September 1968	May 1969
Radionuclides in Institutional Diet Samples, *PHS*	April-June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August-December 1968	December 1969

1. Estimated daily intake of radionuclides in Connecticut standard diet, July–December 1968, January–June 1969

Connecticut State Department of Health

The Connecticut State Department of Health has been analyzing a standard diet on a monthly basis since March 1963. Analyses are made for strontium-89, strontium-90, and gamma-ray emitters.

The standard diet was selected to represent the food intake of an 18-year-old boy for 1 day (table 1). The total weight of the complete blended diet, averaging 3 kilograms, included milk and dairy products. When raw fruit or vegetables were sampled, they were washed before blending.

Table 1. Foods included in standard diet

Bread, white—8 slices
Butter—½ stick
Carrots, scraped—½ cup
Celery, washed and trimmed—3 stalks
Cookies—4
Cottage cheese—⅔ cup
Cupcakes—2
Egg—1
Green beans, washed—½ cup
Ham—85 grams
Hamburger—227 grams
Ice cream—½ pint
Lettuce, washed—4–5 leaves
Milk—3 cups
Oatmeal—uncooked—43 grams
Orange—1
Peanut butter—2½ tablespoons
Pears, canned—2 halves with juice
Potatoes, washed, not peeled—2
Sugar—5 tablespoons
Tomato juice—113 grams
Tuna fish, drained—43 grams

Cesium–137 concentrations were determined by gamma-ray spectrometry (*1*). Strontium–89 and strontium–90 concentrations were determined by chemical separation techniques (*1*).

Table 2 presents the analytical results for the Connecticut standard diet from July–December 1968, table 4 shows January–June 1969 data. Results representative of the total daily intake for the radionuclides observed are presented in tables 3 and 5

Table 2. Radionuclide concentrations in Connecticut standard diet,[a] July–December 1968

Month (1968)	Potassium (g/kg)	Strontium–90 (pCi/kg)	Cesium–137 (pCi/kg)
July	2.0	8.7	10
August	2.1	8.0	30
September	NA	NA	NA
October	1.7	9.3	10
November	2.0	8.5	20
December	NA	NA	NA

[a] All strontium–89 values were <3 for this period.
NA, no analysis.

Table 3. Daily radionuclide intakes in Connecticut standard diet,[a] July–December 1968

Month (1968)	Potassium (g/day)	Strontium–90 (pCi/day)	Cesium–137 (pCi/day)
July	6.0	25.6	40
August	6.4	24.5	90
September	NA	NA	NA
October	5.4	29.6	50
November	6.6	28.0	70
December	NA	NA	NA

[a] All strontium–89 values were <3 for this period.
NA, no analysis.

Table 4. Radionuclide concentrations in Connecticut standard diet,[a] January–June 1969

Month (1969)	Potassium (g/kg)	Strontium–90 (pCi/kg)	Cesium–137 (pCi/kg)
January	2.0	7.1	<10
February	NA	NA	NA
March	2.1	9.7	<10
April	2.0	7.4	10
May	NA	NA	NA
June	2.1	8.9	<10

[a] All strontium–89 values were <3 for this period.
NA, no analysis.

In order to evaluate general trends, strontium-90 and cesium-137 daily intakes are plotted as a function of time in figures 1 and 2.

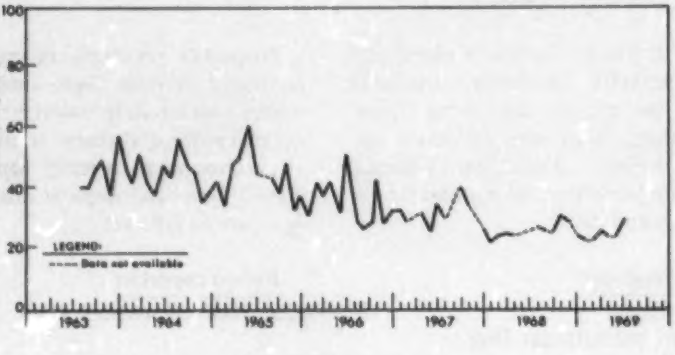

Figure 1. Strontium–90 intake in Connecticut standard diet 1963–June 1969

Table 5. Daily radionuclide intakes in Connecticut standard diet,[a] January–June 1969

Month (1969)	Potassium (g/day)	Strontium-90 (pCi/day)	Cesium-137 (pCi/day)
January	6.2	21.8	<20
February	NA	NA	NA
March	6.3	29.6	<20
April	6.3	23.1	40
May	NA	NA	NA
June	6.5	28.1	<30

[a] All strontium-89 values were <3 for this period.
NA, no analyses.

REFERENCE

(1) CONNECTICUT STATE DEPARTMENT OF HEALTH. Estimated daily intake of radionuclides in Connecticut standard diet, March 1963–December 1964. Radiol Health Data 6:381–382 (July 1965).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	May 1968
January–June 1968	November 1968

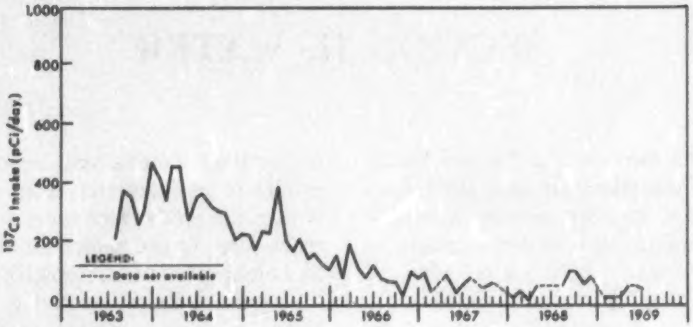

Figure 2. Cesium-137 intake in Connecticut standard diet 1963–June 1969

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SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2–4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposures greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below.

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Colorado River Basin	1967	December 1968
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

Radionuclide Analysis of Coast Guard Supplies January 1968–July 1969

U.S. Coast Guard[1] and
Bureau of Radiological Health[2]

Since 1961, water samples have been collected from seven Coast Guard Loran Stations in Alaska and analyzed for radioactivity. These stations are identified as Adak Island, Attu Island, Biorka Island, Cape Sarichef, Port Clarence, Sitkinak Island, and Spruce Cape. Their locations are shown in figure 1.

The principal source of water for these Loran Stations is either lakes or reservoirs, most of which have ice and snow cover for many of the winter months. Water is piped from the reservoirs to storage tanks at the stations. The storage tanks range in capacity from 25,000 to 225,000 gallons. All of the stations chlorinate the water and all but the Attu Island station filter the water prior to use.

One-gallon samples are collected monthly and sent to the Southwestern Radiological Health Laboratory in Las Vegas, Nev. for analysis. The samples are analyzed routinely for gross alpha and beta radioactivity. Samples are analyzed for specific radionuclides if unusual amounts of gross radioactivity are detected.

Gross alpha and gross beta for the water samples collected during 1968–1969 are shown in table 1.

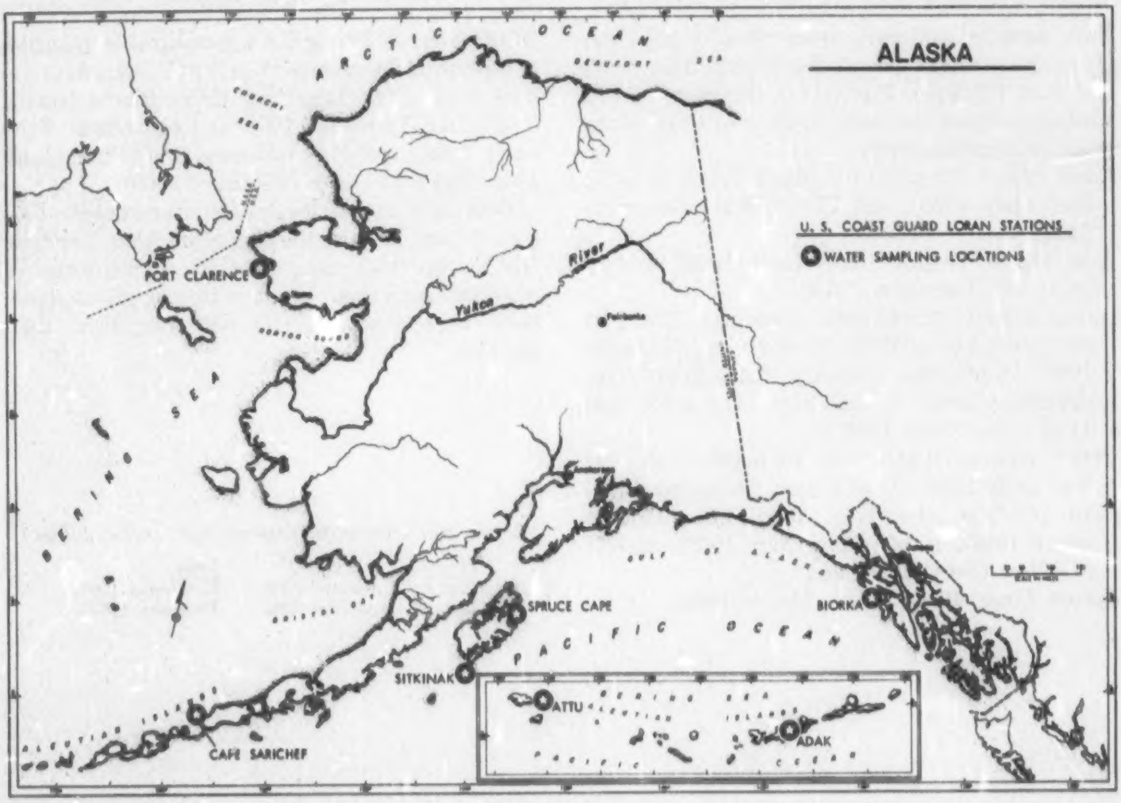
ARCTIC OCEAN
BEAUFORT SEA
CHUKCHI SEA
ALASKA
U. S. COAST GUARD LORAN STATIONS
WATER SAMPLING LOCATIONS
PORT CLARENCE
NORTON SOUND
Yukon River
Fairbanks
BERING SEA
GULF OF ALASKA
BRISTOL BAY
SPRUCE CAPE
BIORKA
PACIFIC OCEAN
SITKINAK
ATTU
ADAK
ALEUTIAN ISLANDS
CAPE SARICHEF

Figure 1. Coast Guard Loran station water sampling locations

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[1] U.S. Department of Transportation.
[2] U.S. Public Health Service.

Table 1. Radioactivity in water samples (pCi/liter) from U.S. Coast Guard Loran stations, January 1968–July 1969

Months	Adak Island		Attu Island		Biorka Island		Cape Sarichef		Port Clarence		Sitkinak Island		Spruce Cape	
	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta	Alpha	Beta
1968														
January	[a] 0	7	0	[a] 0	NS	NS	0	0	0	8	0	8	0	0
February	0	0	0	5	0	12	0	8	0	9	NS	NS	0	0
March	0	10	0	13	0	9	0	0	0	10	NS	NS	0	0
April	0	13	0	5	0	6	0	4	NS	NS	0	4	0	0
May	0	5	0	4	NS	NS	0	3	0	10	0	4	0	0
June	0	4	0	0	NS	NS	0	0	0	20	0	5	0	8
July	0	11	0	0	0	6	0	5	0	13	NS	NS	0	0
August	0	6	0	4	0	11	0	4	0	10	0	6	0	0
September	0	4	0	0	0	10	0	3	0	6	NS	NS	0	0
October	0	0	0	4	0	10	0	0	0	8	0	4	0	0
November	0	8	0	10	NS	NS	0	5	0	10	0	6	0	5
December	0	12	0	13	0	13	0	9	0	11	NS	NS	0	0
1969														
January	0	4	0	8	0	16	0	0	0	8	NS	NS	0	3
February	0	3	0	7	0	15	0	3	6	19	NS	NS	0	7
March	0	7	NS	NS	NS	NS	0	0	0	8	NS	NS	0	19
April	0	3	0	10	0	10	0	3	0	11	0	8	0	3
May	0	4	0	5	8	16	0	6	0	15	NS	NS	0	0
June	0	3	0	0	0	11	0	4	0	11	NS	NS	0	0
July	0	5	0	3	0	5	0	0	0	0	0	4	0	0

[a] Values equal to or less than 2 pCi/liter gross alpha or gross beta radioactivity are reported as zero.
NS, no samples.

Two samples contained more than 3 pCi/liter gross alpha; Biorka Island, 8 pCi/liter (May 1969) and Port Clarence, 6 pCi/liter (February 1969). Twenty samples contained more than 10 pCi/liter gross beta radioactivity

Adak Island: 13 pCi/liter (April 1968), 11 pCi/liter (July 1968), and 12 pCi/liter (December 1968);

Attu Island: 13 pCi/liter (March 1968), and 13 pCi/liter (December 1968);

Biorka Island: 12 pCi/liter (February 1968); 11 pCi/liter (August 1968), 13 pCi/liter (December 1968), 16 pCi/liter (January 1969), 15 pCi/liter (February 1969), 16 pCi/liter (May 1969), and 11 pCi/liter (June 1969);

Port Clarence, 20 pCi/liter (June 1968); 13 pCi/liter (July 1968); 11 pCi/liter (December 1968) 19 pCi/liter (February 1969), 11 pCi/liter (April 1969), 15 pCi/liter (May 1969), and 11 pCi/liter (June 1969); and

Spruce Cape, 19 pCi/liter (March 1969).

Of these the following had a measureable quantity of strontium–90 greater than 2 pCi/liter: Attu Island, 3 pCi/liter (December 1968); Biorka Island, 3 pCi/liter (December 1968) and 4 pCi/liter (February 1969); and Port Clarence, 6 pCi/liter (June 1968) and 6 pCi/liter (February 1969).

Because of the low levels of environmental radioactivity and because the Radiation Alert Network (RAN) provides comprehensive surveillance of Alaskan Loran stations, the water supply analyses have been discontinued with the July 1969 samples.

Previous coverage in *Radiological Health Data and Reports:*

Period	Issue
January–December 1966	November 1967
January–December 1967	February 1969

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta-radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

An intercomparison of the above networks was performed by Lockhart and Patterson in 1962 and is summarized in the January 1964 issue of *Radiological Health Data*. In addition to those programs presented in this issue, the following program was previously covered in *Radiological Health Data and Reports*.

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969

1. Radiation Alert Network
October 1969

Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports*.

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during October 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting station.

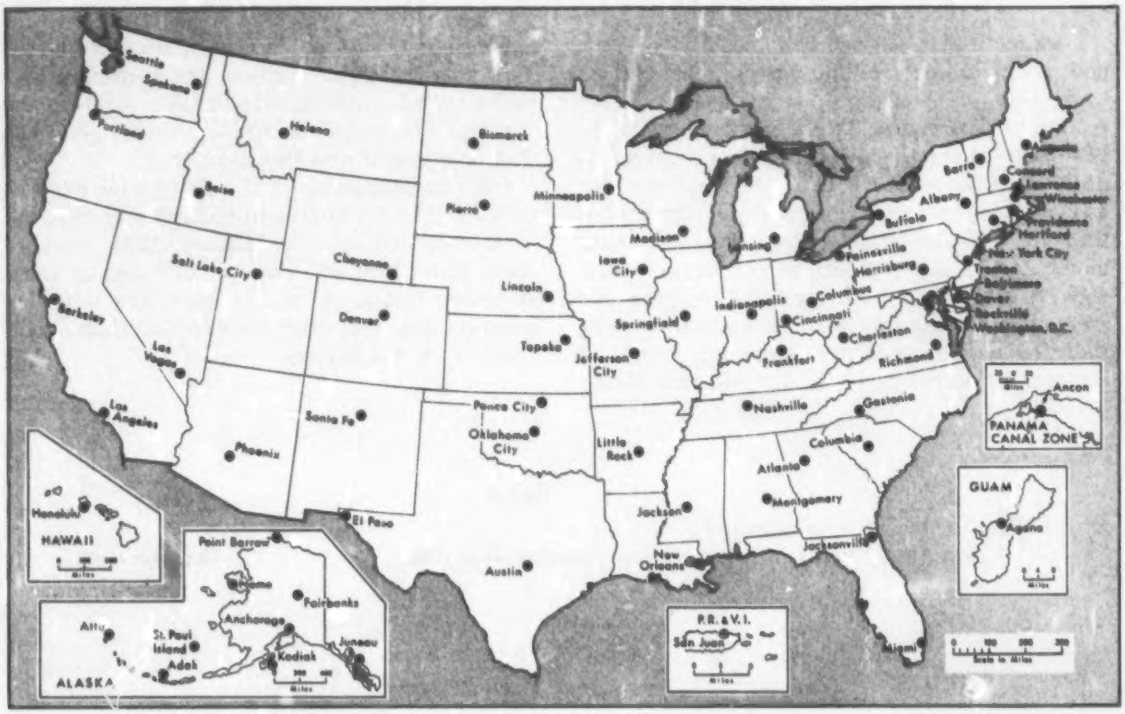
Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Salt Lake City
Cheyenne
Lincoln
Berkeley
Denver
Topeka
Las Vegas
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Phoenix
El Paso
Austin
Madison
Iowa City
Springfield
Jefferson City
Little Rock
Lansing
Indianapolis
Columbus
Cincinnati
Frankfort
Charleston
Painesville
Harrisburg
Buffalo
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Richmond
Nashville
Gastonia
Columbia
Atlanta
Montgomery
Jackson
New Orleans
Jacksonville
Miami
Ancon
PANAMA CANAL ZONE
Miles
GUAM
Agana
Miles
P.R. & V.I.
San Juan
Miles
0 100 200 300
Scale in Miles
HAWAII
Honolulu
0 100 200
Miles
ALASKA
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
0 200 400
Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, October 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
			Maximum	Minimum	Average[a]		Number of samples	Total depth (mm)	Field estimation of deposition: Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	24	6	1	2	Dec 69	2	40	2	40	17
Alaska:	Adak	25	1	1	1	Dec 69	(c)				
	Anchorage	6	0	0	0	Aug 69	(c)				
	Attu Island	17	0	0	0	Jan 70	(c)				
	Fairbanks	22	3	0	1	Sept 69	3	4	3	4	4
	Juneau	22	4	0	1	Oct 69	9	70	9	70	0
	Kodiak	12	1	0	0	Nov 69	(c)				
	Nome	30	3	0	1	May 69	(c)				
	Point Barrow	29	0	0	0	Feb 70	(c)				
	St. Paul Island	(b)				June 69	(c)				
Ariz:	Phoenix	20	12	1	6	Oct 69	(c)				
Ark:	Little Rock	13	6	0	2	Aug 69	1	19	1	19	0
Calif:	Berkeley	22	2	0	1	Nov 69	3	65	3	65	1
	Los Angeles	21	4	1	2	May 69	(c)				
C.Z:	Ancon	19	1	0	0	Nov 69	(c)				
Colo:	Denver	22	6	0	1	Nov 69	7	72	(d)		
Conn:	Hartford	22	1	0	0	Sept 69	4	122	4	122	0
Del:	Dover	22	3	0	1	July 69	(c)				
D.C:	Washington	27	2	0	0	Feb 70	2	16	2	16	0
Fla:	Jacksonville	22	1	0	1	Aug 69	11	1,626	11	1,626	70
	Miami	16	0	0	0	Sept 69	9	215	3	103	0
Ga:	Atlanta	22	2	1	1	June 69	1	40	1	49	17
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	29	1	0	1	Jan 70	1	4	(d)		
Idaho:	Boise	22	5	1	3	Jan 70	8	17	8	17	2
Ill:	Springfield	11	2	0	1	Feb 70	(c)				
Ind:	Indianapolis	(b)				June 69	(c)				
Iowa:	Iowa City	22	3	0	1	Nov 69	6	90	6	90	0
Kans:	Topeka	23	5	0	2	Aug 69	6	100	6	100	3
Ky:	Frankfort	16	4	1	2	Feb 70	(c)				
La:	New Orleans	23	1	0	1	Feb 70	5	18	(d)		
Maine:	Augusta	23	2	0	1	Oct 69	10	56	9	53	0
Md:	Baltimore	22	1	0	1	Sept 69	4	26	4	26	0
	Rockville	11	1	0	0	Jan 70	(c)				
Mass:	Lawrence	18	4	0	1	Nov 69	3	31	3	31	0
	Winchester	25	4	0	1	Dec 69	5	45	5	45	0
Mich:	Lansing	22	5	0	1	Jan 70	7	61	7	61	7
Minn:	Minneapolis	23	2	0	1	July 69	4	44	4	44	2
Miss:	Jackson	16	1	0	1	Oct 69	3	144	3	144	15
Mo:	Jefferson City	22	3	0	1	June 69	6	151	6	151	0
Mont:	Helena	22	4	0	2	Dec 69	5	36	4	18	6
Nebr:	Lincoln	6	9	2	4	June 69	2	19	2	19	3
Nev:	Las Vegas	17	2	0	1	Sept 69	(c)				
N.H:	Concord	16	2	0	1	Feb 70	(c)				
N.J:	Trenton	21	3	0	1	Oct 69	3	32	3	32	1
N. Mex:	Santa Fe	16	6	0	1	Dec 69	7	74	7	74	10
N.Y:	Albany	14	2	0	1	June 69	4	36	4	36	18
	Buffalo	20	2	0	1	Nov 69	(c)				
	New York City	21	1	0	1	Dec 69	(c)				
N.C:	Gastonia	18	10	0	5	Nov 69	4	46	(d)		
N. Dak:	Bismarck	23	6	1	3	Feb 70	4	5	4	5	1
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	3	2	1	1	Oct 69	1	18	(e)		
	Painesville	22	2	0	1	Sept 69	11	111	11	111	9
Okla:	Oklahoma City	13	4	0	2	Jan 70	6	34	5	31	1
	Ponca City	22	7	0	2	Sept 69	4	44	4	44	0
Ore:	Portland	21	2	0	1	June 69	13	98	13	98	6
Pa:	Harrisburg	22	2	0	1	June 69	(c)				
P.R:	San Juan	(b)				Oct 69	(c)				
R.I:	Providence	22	8	0	1	Jan 70	5	52	5	52	6
S.C:	Columbia	20	5	0	2	Dec 69	1	21	1	21	0
S. Dak:	Pierre	10	6	1	4	Oct 69	(c)				
Tenn:	Nashville	22	4	0	1	Jan 70	6	42	6	42	0
Tex:	Austin	22	7	1	4	July 69	(c)				
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	31	4	0	2	May 69	8	43	8	43	10
Vt:	Barre	19	5	0	2	Aug 69	7	57	7	57	7
Va:	Richmond	23	2	0	1	Aug 69	2	52	2	52	6
Wash:	Seattle	4	0	0	0	Aug 69	7	39	(d)		
	Spokane	22	4	1	2	July 69	(c)				
W. Va:	Charleston	21	4	0	2	Dec 69	4	48	4	48	7
Wisc:	Madison	23	2	0	1	Aug 69	7	78	6	77	11
Wyo:	Cheyenne	23	5	0	1	Sept 69	6	56	6	56	2
Network summary		1,321	12	0	1		6	103	5	95	6

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

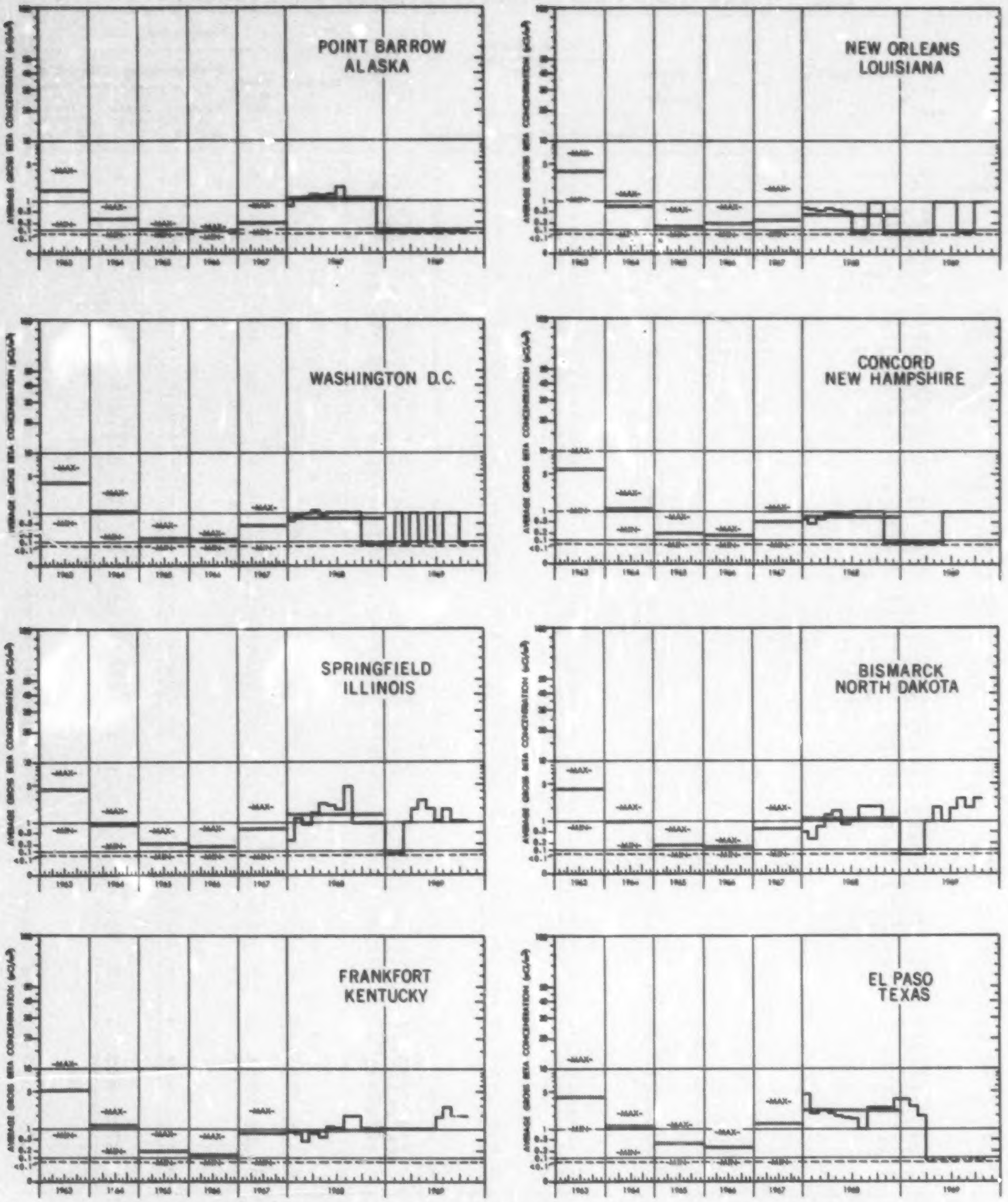

Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–October 1969

2. Canadian Air and Precipitation Monitoring Program[1], October 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports.*

Surface air and precipitation data for October 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, October 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m^3)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m^2)
Calgary	31	0.2	0.0	0.1	29	0.9
Coral Harbour	31	.1	.0	.1	NS	NS
Edmonton	29	.2	.0	.1	40	1.2
Ft. Churchill	21	.1	.0	.1	19	.9
Ft. William	31	.2	.0	.1	59	2.3
Fredericton	31	.2	.0	.1	31	1.9
Goose Bay	31	.1	.0	.1	15	.8
Halifax	30	.2	.0	.1	22	2.2
Inuvik	31	.1	.0	.1	396	.5
Montreal	31	.2	.0	.1	27	2.3
Moosonee	30	.2	.0	.1	10	.6
Ottawa	31	.2	.0	.1	15	.6
Quebec	31	.1	.0	.1	37	2.8
Regina	31	.2	.0	.1	16	1.0
Resolute	30	.1	.0	.1	10	.2
St. John's, Nfld	29	.2	.0	.1	15	3.0
Saskatoon	31	.2	.0	.1	18	1.2
Saulte Ste. Marie	31	.2	.0	.1	21	3.0
Toronto	30	.3	.0	.1	40	2.3
Vancouver	31	.2	.0	.1	38	3.7
Whitehorse	31	.1	.0	.1	255	.6
Windsor	31	.2	.0	.1	23	1.2
Winnipeg	31	.2	.0	.1	63	1.7
Yellowknife	31	.1	.0	.1	102	1.3
Network summary	726	0.3	0.0	0.1	59	1.6

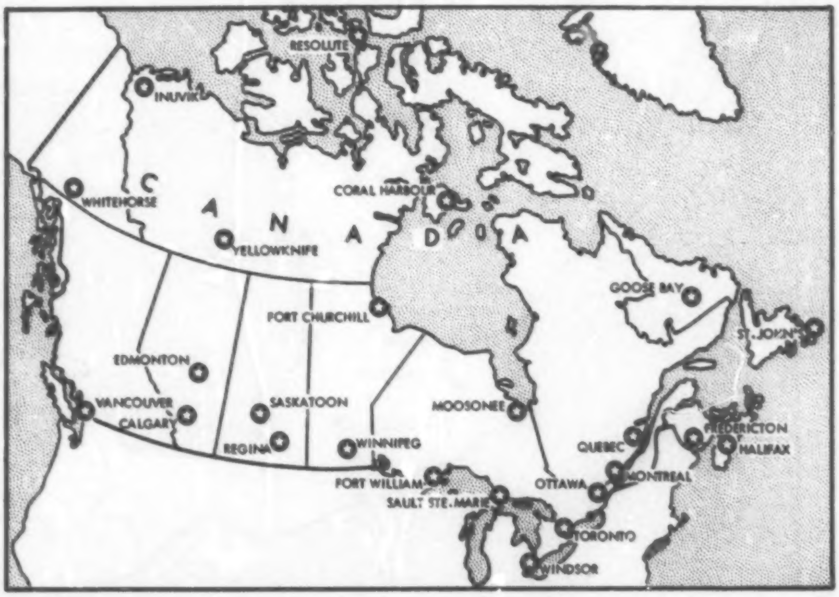
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
MOOSONEE
QUEBEC
FREDERICTON
HALIFAX
FORT WILLIAM
SAULT STE. MARIE
OTTAWA
MONTREAL
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

3. Mexican Air Monitoring Program
May and June 1969

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CNEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F., Mérida, Veracruz, San Luis Potosí, and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de México, the Chemistry Department of the University of Mérida, the Institute de Zonas Deserticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency 6- by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Seccion de Radioactividad Ambiental, CNEN, in Mexico, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month was needed to get a reliable average radioactivity at each station (*6*).

The maximum, minimum, and average beta radioactivity in surface air during May and June 1969 are presented in tables 3 and 4.

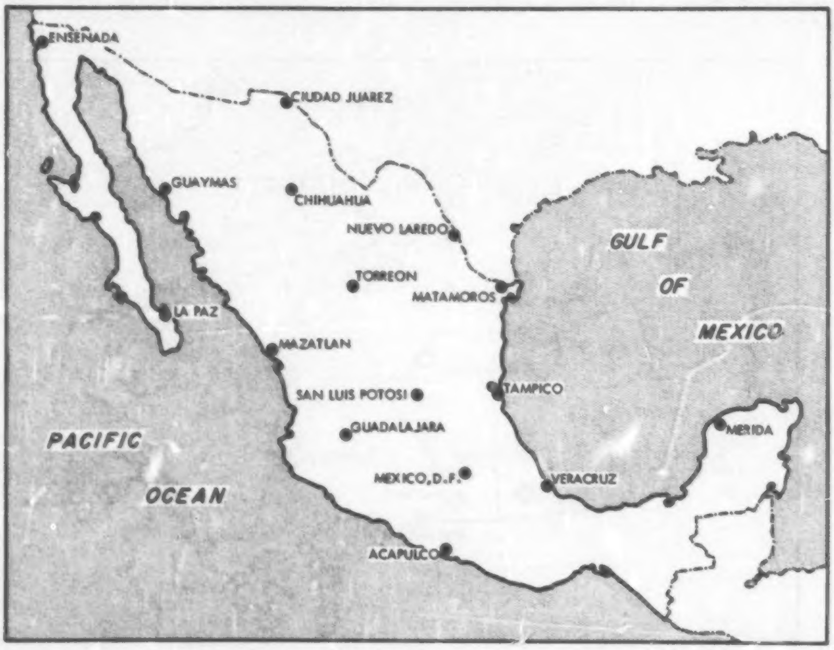

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, May 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	15	0.6	0.1	0.3
Ciudad Juares	1	.6		
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	NS			
Matamoros	NS			
Mazatlan	3	.6	.5	.5
Mérida	15	.5	.1	.3
México, D.F.	1	.2		
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	7	1.4	.1	.1
Veracruz	8	.1	.6	.3

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, June 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	19	0.8	0.3	0.3
Chihuahua	9	1.6	.5	.9
Ciudad Juares	NS			
Ensenada	4	.7	.2	.4
Guadalajara	NS			
Guaymas	NS			
La Paz	10	.7	.2	.4
Matamoros	NS			
Mazatlan	NS			
Mérida	3	.3	.1	.3
México, D.F.	NS			
Nuevo Laredo	7	1.5	.2	.9
San Luis Potosí	NS			
Tampico	NS			
Torreón	22	.7	.1	.5
Veracruz	11	1.2	.1	.5

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program October 1969

Pan American Health Organization and
U.S. Public Health Service

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health program.

Table 5. Summary of gross beta radioactivity in Pan American surface air, October 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	21	0.18	0.05	0.10
Bolivia:	La Paz	17	.12	.03	.07
Chile:	Santiago	29	.27	.04	.13
Colombia:	Bogota	20	.04	.00	.01
Ecuador:	Cuenca	NS	NS	NS	NS
	Guayaquil	5	.08	.02	.06
	Quito	11	.04	.00	.01
Guyana:	Georgetown	NS	NS	NS	NS
Jamaica:	Kingston	19	0.24	.01	.06
Peru:	Lima	NS	NS	NS	NS
Venezuela:	Caracas	22	.08	.01	.02
West Indies:	Trinidad	22	.04	.00	.02
Pan American summary		166	0.27	0.00	0.06

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ arereported and used in averaging as 0.00 pCi/m³.

NS, no sample.

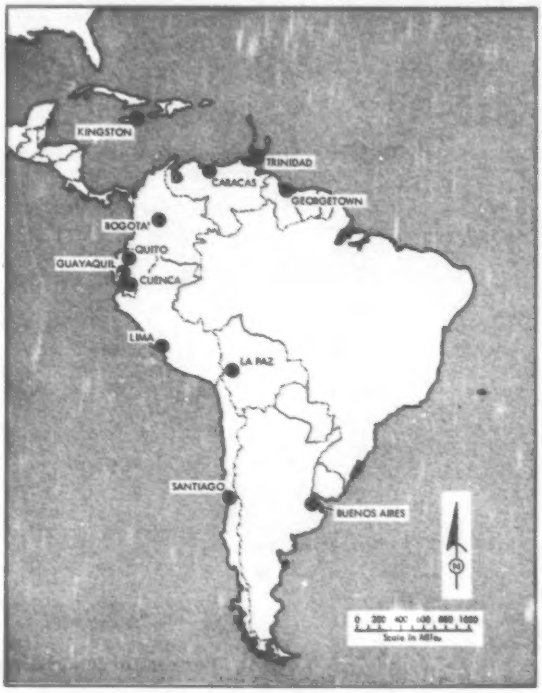

Figure 5. Pan American Air Sampling Program stations

The air sampling locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiological Health Data and Reports*. The October 1969 air monitoring results from the participating countries are given in table 5.

5. Plutonium in Airborne Particulates and Precipitation, July–September 1968

Bureau of Radiological Health
U.S. Public Health Service

The Radiation Alert Network (RAN) of the Bureau of Radiological Health, Public Health Service, routinely analyzes airborne particulate and precipitation samples from selected RAN stations for plutonium. The airborne particulate and precipitation analyses were initiated in November 1965 and August 1966, respectively, and the results through June 1968 have been previously reported (*7–15*).

Air filters from 11 RAN stations are analyzed for plutonium. A monthly composite is made of one-half of each individual air filter from each of the 11 stations and sent to the PHS Northeastern Radiological Health Laboratory (NERHL) for analysis. Eight RAN stations submit complete collections of precipitation for plutonium analysis. An 8-liter (or whatever is available) aliquot of the monthly collection of each of the 8 stations is forwarded to the NERHL for analysis. The analytical methodology for processing these samples is described in the December 1968 issue of *Radiological Health Data and Reports* (*14*).

The results for July through September 1968 are presented in tables 6 and 7. ND (nondetectable) has been used to indicate samples containing plutonium–238 or plutonium–239 activities less than or equal to the appropriate minimum detectable activities (.020 pCi and .015 pCi per sample for plutonium–238 and plutonium–239, respectively). Sample size varies, generally ranging from 20,000 to 30,000 cubic meters of air for the air filter samples, and from 2 to 8 liters for the precipitation samples.

Table 6. Plutonium–238 and plutonium–239 in precipitation, July–September 1968

	Anchorage	Denver	Honolulu	New Orleans	Gastonia	Rockville	Austin	Seattle
Precipitation depth (mm): July–September	61	87	20	71	59	95	65	142
Concentration (pCi/liter): Plutonium–239 July–September	.056	.022	ND	.107	.021	.015	ND	.047
Plutonium–238 July–September	ND	ND	ND	.129	ND	ND	.059	ND
Deposition (pCi/m^2): Plutonium–239 July–September	3.36	1.87		7.49	1.21	1.30		6.58
Plutonium–238 July–September				9.03			3.84	

ND, nondetectable.

Table 7. Plutonium in airborne particulates, July–September 1968

	Buffalo	Gastonia	Rockville	Pierre	New Orleans	Austin	Denver	Anchorage	Phoenix	Honolulu	Seattle
Plutonium–238 (fCi/m^3) July–September...	ND	0.024	ND	0.045	ND	ND	ND	ND	ND	ND	0.033
Plutonium–239 (fCi/m^3) July–September...	.098	.124	.056	.176	.091	.071	.060	.052	.102	.031	.041
^{239}Pu/^{238}Pu July–September...		5.17		3.91							1.24

ND, nondetectable.

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REFERENCES

(*1*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW–RP–3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(*2*) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW–RP–4. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(*3*) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW–RP–5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(*4*) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD–11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(*5*) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD–21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(*6*) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Méxicana, 1963–1965. Comisión Nacional de Energía Nuclear, Direccion General de Seguridad Radiologica (1966).

(*7*) RUSSELL, J., H. LEVINE, R. SCHNEIDER. Plutonium in airborne particulates, November 1965 through March 1966. Radiol Health Data Rep 7:483–484 (August 1966).

(*8*) DIVISION OF RADIOLOGICAL HEALTH. Plutonium in airborne particulates, April–June 1966. Radiol Health Data Rep 7:666–667 (November 1966).

(*9*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, July–September 1966. Radiol Health Data Rep 8:108–109 (February 1967).

(*10*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, October–December 1966. Radiol Health Data Rep 8:288–289 (May 1967).

(*11*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates, January–March 1967. Radiol Health Data Rep 8:534 (September 1967).

(*12*) LEVINE, H., W. P. KIRK, H. J. L. RECHEN. Plutonium and strontium-90 in precipitation, August 1966 through March 1967. Radiol Health Data Rep 8:574–576 (October 1967).

(*13*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation and strontium-90 in precipitation, April–June 1967. Radiol Health Data Rep 8:662–663 (November 1967).

(*14*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, July–December 1967. Radiol Health Data Rep 9:761–763 (December 1968).

(*15*) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Plutonium in airborne particulates and precipitation, January–March 1968. Radiol Health Data Rep 10:34–35 (January 1969).

SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance, and environmental monitoring around nuclear facilities.

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Argonne National Laboratory and the Rocky Flats Plant.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

1. Argonne National Laboratory[2]
July–December 1968

University of Chicago
Lemont, Ill.

The radioactivity of the environment is determined on a continuing basis by measuring the radioactivity in naturally-occurring materials collected both on and off the Argonne National Laboratory site. Since radioactivity is usually spread by air and water, the environmental monitoring program at Argonne has concentrated on these materials. The sampling locations discussed in this report are shown in figures 1 and 2.

Air monitoring

Air-filter samples were collected continuously at seven locations on the Argonne site and at five locations off the site. The alpha and beta radioactivity in airfilter samples are summarized in table 1. The alpha radioactivity concentrations were normal both on and off the site and in the range found in previous years. As in the past, much of the beta and gamma radioactivity was due to fission and neutron activation products from nuclear detonations, although about one-third of the gamma radioactivity and a smaller fraction of the beta radioactivity was due to beryllium–7, produced continuously in the upper atmosphere by cosmic-ray interactions. The variation in total beta radioactivity during the year can be correlated with the concentrations of the individual gamma-ray emitters. The beta radioactivity decreased during the year from an average of 0.25 pCi/m^3 during the first half to an average of 0.12 pCi/m^3 during the last 6 months. This decrease was due to the disappearance by radioactive decay of the shorter-lived fission products, primarily zirconium–niobium–95. By the end of the year, the short-lived fission products were below their minimum detectable concentrations, although traces of these nuclides (<0.01 pCi/m^3) were also detected in August and September. While the longer-lived gamma-ray emitters also decreased somewhat in concentration during the

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[2] Summarized from "Environmental Radioactivity at Argonne National Laboratory, July–December 1968," University of Chicago, Lemont, Ill.

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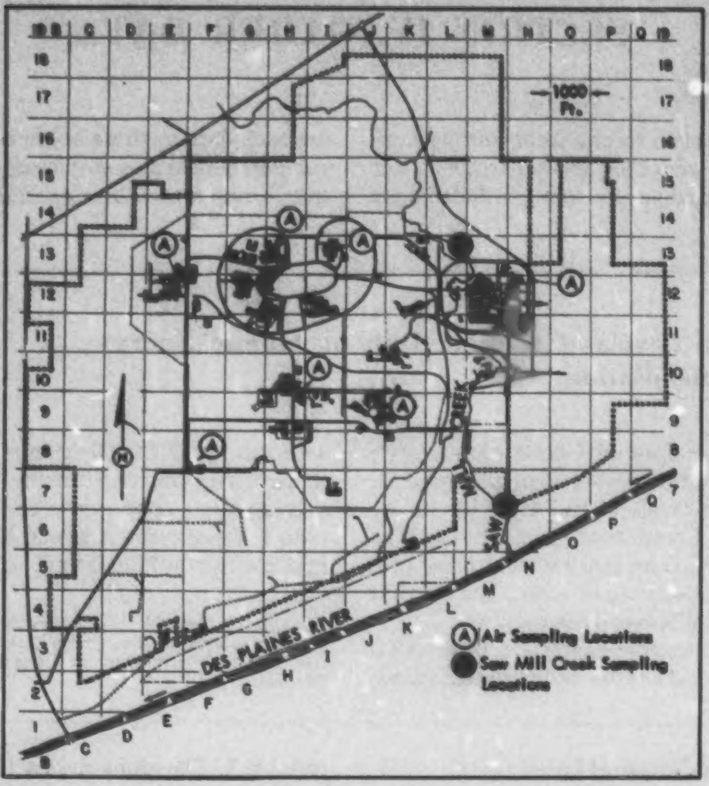

Figure 1. Onsite sampling locations at Argonne National Laboratory

Table 1. Alpha and beta radioactivity in air-filter samples,[a] Argonne National Laboratory, July–December 1968

Period	Location	Number of samples	Alpha radioactivity (pCi/m³) Multiply by 10^{-2}			Beta radioactivity (pCi/m³) Multiply by 10^{-1}		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Onsite	27	0.40	0.20	1.02	0.21	0.09	0.32
	Offsite	23	.58	.27	1.38	.22	.15	.32
August	Onsite	25	.42	.22	.85	.15	.10	.25
	Offsite	22	.36	.11	.58	.16	.08	.27
September	Onsite	24	.47	.23	.55	.13	.09	.16
	Offsite	17	.52	.27	1.01	.13	.09	.19
October	Onsite	24	.43	.18	1.15	.09	.05	.14
	Offsite	23	.51	.24	1.22	.09	.06	.14
November	Onsite	26	.25	.10	.30	.06	.03	.11
	Offsite	19	.30	.08	.51	.08	.04	.14
December	Onsite	22	.36	.16	.32	.07	.03	.14
	Offsite	17	.35	.16	.50	.08	.03	.16
Annual summary	Onsite	301	0.42	0.10	1.15	0.18	0.03	0.51
	Offsite	230	0.48	0.08	1.38	0.19	0.03	0.51

[a] These results were obtained by measuring the samples 4 days after they were collected in order to avoid counting the natural radioactivity due to radon and thoron decay products.

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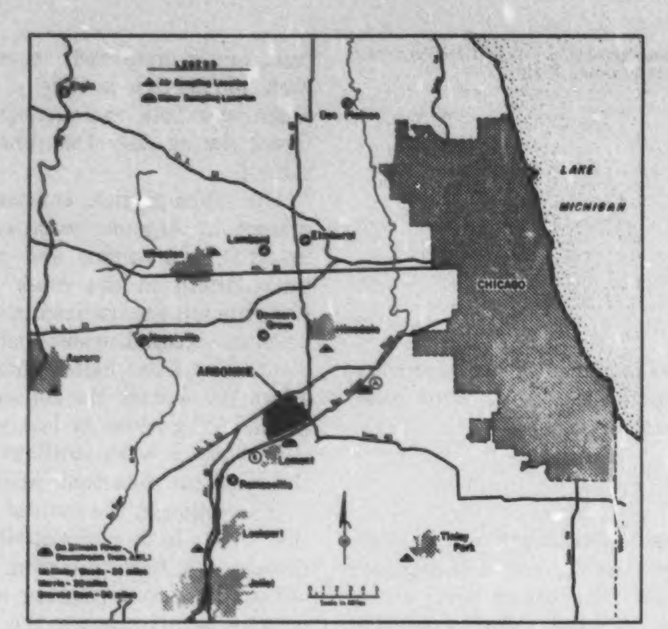

Figure 2. Location of Argonne National Laborat (including some offsite sampling stations)

last half of the year, their effect on the total beta radioactivity was not as marked because they were present in lower concentrations than the short-lived activities. Precipitation collected on the site contained the same fission products found in the air samples. Large volume rain samples were also analyzed for iron-55, a neutron activation product produced in nuclear detonations. Monthly composite samples were analyzed for this nuclide from July to December 1968. Concentrations ranged from 0.014 to 0.14 nCi/m^3 and averaged 0.048 nCi/m^3 (corrected for decay back to October 15, 1961).

Sampling on charcoal, specifically for gaseous radioiodine, was conducted continuously on the site. No activity above the minimum detectable concentration of 0.1 pCi/m^3 was detected during this time period.

Air sampling for argon-41, which is produced in the reactor by neutron activation of the stable argon in the air used for cooling, was conducted near the CP-5 reactor (Building 330) beginning in May. The sampling locations ranged from 50 to 565 yards from the reactor. Results are tabulated in table 2. The average and maximum concentrations of 140 and 1,400 nCi/m^3 are about 3.5 and 35 times greater than the AEC standard for argon-41 (40 nCi/m^3). However, each sample was collected over a period of about 1 minute and was taken downwind after the reactor had been in operation for several hours. Therefore, the actual average concentration in the 300 area was much less than the values in the table.

Table 2. Argon-41 concentrations near CP-5 reactor, May–December 1968

Month	Number of samples	Number of samples >20 nCi/m^3	Concentration (nCi/m^3)	
			Average	Minimum
May	7	4	150	800
June	16	11	180	850
July	31	11	110	1,400
August	34	21	130	730
September	34	15	80	270
October	30	13	130	990
November	32	14	150	750
December	26	8	160	570

Air sampling for tritiated (hydrogen-3) water vapor was carried out 50-yards west of the CP-5 reactor. The results are given in table 3. The maximum concentration corresponds to 0.88 percent of the AEC standard (200 nCi/m^3). Control samples collected in the east area contained less than the minimum detectable concentration of

Table 3. Hydrogen-3 concentrations near CP-5 reactor June-December 1968

Month	Number of samples	Concentration (pCi/m³)			Percent AEC standard	
		Average	Minimum	Maximum	Average	Maximum
June	10	28	<15	47	0.014	0.024
July	26	270	<15	1,760	.14	.88
August	12	84	<15	570	.042	.29
November	1			120		.060
December	5	210	<15	640	.11	.32

15 pCi/m³. Tritium is produced in the reactor by the action of neutrons on the heavy water used for cooling and moderating.

Water monitoring

Argonne wastewater is discharged into Sawmill Creek, a stream that runs through the Argonne grounds and enters the Des Plaines River about 500-yards downstream from the wastewater discharge. Sawmill Creek was sampled above and below the discharge to evaluate the effect of the wastewater on the radioactivity in the creek. The sampling locations are shown in figure 2.

Below the wastewater outfall, the creek was usually sampled three to five times weekly. Since it was impractical to analyze all the samples for all the radionuclides and elements desired, equal portions of the three samples collected each week were combined and analyzed. The results obtained in this way represent the average concentrations in the weekly samples. Above the site, samples were collected at semimonthly intervals, and at least one sample each month was analyzed for each radioactive nuclide of interest. The total alpha and beta radioactivity found in Sawmill Creek during July–December 1968 are given in table 4.

The alpha-particle emitters most likely to be present in Argonne wastewater are isotopes of uranium, plutonium, and thorium. The alpha radioactivity in the creek water due to these elements are summarized in table 5. The average uranium concentrations below the outfall was about 30 percent higher than during 1967; while above the outfall, the concentration averaged essentially the same as last year. The plutonium and thorium concentrations averaged less than the minimum detectable amount.

In addition to the natural beta radioactivity in the creek, beta radioactivity from fallout was detected at both sampling locations and beta radioactivity from Argonne wastewater was found in some samples below the outfall. The natural beta radioactivity is approximately 5 pCi/liter above the site and 3 pCi/liter below the site. It is estimated that fallout activity added an average of about 11 pCi/liter to the beta radioactivity at both locations, and that the Argonne contribution below the outfall averaged approximately 7 pCi/liter, about one-third less than in 1967.

Since Sawmill Creek empties into the Des Plaines River, which in turn flows into the Illinois River, the radioactivity in the latter two streams is important in assessing the contribution of Argonne wastewater to the environmental radioactivity. The Des Plaines River was sampled

Table 4. Non-volatile alpha and beta radioactivity in Sawmill Creek water, Argonne National Laboratory July–December 1968

Month (1968)	Location[a]	Number of samples	Alpha radioactivity (pCi/liter)			Beta radioactivity (pCi/liter)		
			Average	Minimum	Maximum	Average	Minimum	Maximum
July	Upstream	2	1.7	1.5	1.9	18	15	20
	Downstream	12	1.3	1.0	1.7	11	7	14
August	Upstream	2	2.2	1.8	2.6	16	9	24
	Downstream	15	2.1	1.2	3.0	12	8	16
September	Upstream	2	3.1	2.8	3.4	25	21	25
	Downstream	12	1.4	.6	2.2	10	9	12
October	Upstream	2	3.7	3.6	3.8	23	16	29
	Downstream	12	1.9	1.0	3.3	11	10	12
November	Upstream	2	2.1	2.0	2.3	19	13	26
	Downstream	17	1.9	1.3	2.7	15	12	20
December	Upstream	2	2.3	2.1	2.4	9	8	11
	Downstream	20	2.8	2.4	4.0	13	11	14
July–December 1968 summary	Upstream	12	2.5	1.5	3.8	18	8	29
	Downstream	88	1.9	0.6	4.0	12	7	20
Annual summary	Upstream	24	2.8	1.5	4.5	16	8	33
	Downstream	166	2.4	0.6	9.9	21	7	93

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

Table 5. Alpha-particle emitting elements in Sawmill Creek water, Argonne National Laboratory July–December 1968

Element	Location[a]	Number of samples	Concentration (pCi/liter)			Average as a percent of AEC standard
			Average	Minimum	Maximum	
Uranium	Upstream	7	1.4	0.8	2.1	0.004
	Downstream	36	1.3	.5	1.9	.003
Plutonium	Upstream	6			< .05	
	Downstream	12	<0.05	<.05	.06	< .001
Thorium	Upstream	6			< .05	
	Downstream	12	< .05	<.05	.14	< .003

[a] Relative sampling location with respect to Argonne wastewater outfall (figure 1).

monthly above the mouth of Sawmill Creek and weekly below the mouth to determine if the radioactivity in the creek had any effect on the radioactivity in the river. The total radioactivity is summarized in table 6. The average concentrations were very similar at both locations, indicating that Sawmill Creek water had no significant effect on the radioactivity in the river. The alpha and beta radioactivities were not significantly different from the 1967 averages. The natural beta radioactivity in the river is 5 to 10 pCi/liter, and the additional radioactivity, about 7 pCi/liter on the average, was due to fallout. The total activities in samples of Illinois River water were similar to those found in other bodies of water in the area and to the activities found previously at these same locations, and no radioactivity originating at Argonne could be detected.

Table 6. Average radioactivity in Des Plaines and Illinois River water, Argonne National Laboratory, July–December 1968

Location	Concentration (pCi/liter)	
	Non-volatile alpha radioactivity	Non-volatile beta radioactivity
Des Plaines River[a] (above Sawmill Creek)	3.7	15
Des Plaines River[b] (below Sawmill Creek)	3.4	14
Illinois River[c]	1.7	9

[a] Samples near Route 45, upstream from the mouth of Sawmill Creek.
[b] Sampled near Lemont, downstream from the mouth of Sawmill Creek.
[c] Average for samples collected at four locations (McKinley Woods State Park, June 6 and October 9, Morris, and Starved Rock State Park on October 9, 1968.

Radioactivity in milk

Raw milk was collected monthly from a local dairy farm and analyzed for several fission products. Strontium–89, iodine–131, and barium–140, were not present in concentrations greater than the minimum detectable amounts of 20 pCi/liter for iodine–131 and 3 pCi/liter for the other two radionuclides. The strontium–90 and cesium–137 concentrations are given in table 7. These two radionuclides are long-lived fission products from past nuclear tests and their presence in milk is not related to Argonne operations. The strontium–90 content averaged approximately 25 percent lower, and the cesium–137 content about 40 percent lower than during 1967.

Table 7. Fission product concentrations in milk ANL, July–December 1968

Data collected	Concentrations (pCi/liter)	
	Cesium–137	Strontium–90
January 3	30	5.8
February 7	30	5.8
March 6	35	7.7
April 4	30	8.8
May 2	46	8.6
June 5	60	7.0
July 3	35	3.8
August 7	26	2.7
September 4	37	3.1
October 2	25	5.5
November 6	29	2.2
December 4	45	5.9
Average	36	5.6

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–December 1967	August 1968
January–June 1968	May 1969

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2. Rocky Flats Plant[3]
January–June 1969

Dow Chemical Company
Golden, Colo.

The Rocky Flats Plant (RFP) is engaged in routine production operations involving plutonium and uranium under contract to the Atomic Energy Commission. Its location, relative to population centers, is shown in figure 3. To assure properly controlled releases of radioactive materials to the environment, periodic samples of air, water, and vegetation are analyzed for gross alpha radioactivity. The most abundant radioactive material involved in the process is plutonium.

The plant is located about 10 air miles northwest of Denver. The surface stratum in this area consists of gravel washed out of the highly mineralized front range of the Rocky Mountains, where heterogeneous low-level deposits of uranium, thorium, and radium exist in the soil. These materials are measurable in most samples of air, water, and vegetation.

Air

Continuous air samples were collected at Coal Creek Canyon, Marshall, Boulder, Lafayette, Broomfield, Wagner School, Golden, Denver, and Westminster. The monthly average long-lived gross alpha radioactivity shown in table 6 is believed to result from naturally occurring materials. All values are less than the AEC standard of 40 fCi/m^3 for mixtures of unidentified radionuclides.

Table 6. Long-lived gross alpha radioactivity in airborne particulates, RFP environs, January–June 1969

Period	Average concentration (fCi/m^3)
January	5
February	4
March	3
April	4
May	3
June	3

Water

Regular water samples were obtained monthly except during the winter months from four reser-

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[3] Summarized from "Environmental Survey, January–June 1969," The Dow Chemical Company, Rocky Flats Division, Golden, Colo.

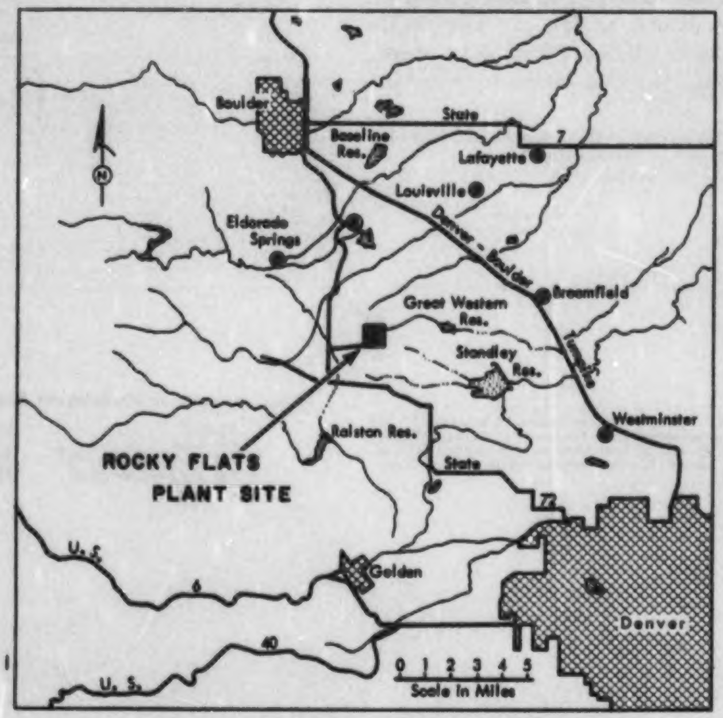
Boulder
State
7
Baseline Res.
Lafayette
Louisville
N
Eldorado Springs
Denver - Boulder
Broomfield
Great Western Res.
Standley Res.
Westminster
Ralston Res.
State
72
ROCKY FLATS PLANT SITE
U.S.
6
Golden
Denver
40
U.S.
0 1 2 3 4 5
Scale in Miles

Figure 3. Location of Rocky Flats Plant

voirs in the area of the Rocky Flats Plant. The results of alpha radioactivity analyses performed on these samples are given in table 7. Following a fire on May 11, 1969, in a plutonium-processing building (appendix 1), additional samples were collected from Great Western and Standley Reservoirs. For comparison purposes, the AEC standard for mixtures of unidentified radionuclides in water is 10 pCi/liter.

Table 7. Alpha radioactivity in water, RFP environs, January–June 1969

Reservoir	Number of samples	Average concentration (pCi/liter)
Great Western	20	2.2
Standley	20	1.8
Baseline	3	.9
Ralston	6	3.4
All other locations (collected May–June 1969)	52	1.8

Vegetation

Vegetation samples collected in October 1968 and May 1969 are summarized in table 8.

Table 8. Alpha radioactivity in vegetation, RFP environs

Collection period	Distance from plant	Number of samples	Average concentration (pCi/kg dry weight)
October 1968	<4 miles	62	90
	4–18 miles	44	96
May 1969	<4 miles	39	84
	4–18 miles	20	77

Recent coverage in *Radiological Health Data and Reports*:

Period	Issue
July–December 1968	June 1969

Appendix I.

Report on the fire at the Rocky Flats Plant near Boulder, Colo., by the U.S. Atomic Energy Commission on May 11, 1969[1]

On May 11, 1969, a major fire occurred at the Rocky Flats (Colorado) Plant of the Atomic Energy Commission (AEC). The Rocky Flats Plant, which produces plutonium parts for nuclear weapons, is located approximately 10 air miles northwest of Denver, between Golden and Boulder. The facility is operated for the AEC by the Dow Chemical Company under a contract administered by the Rocky Flats Area Office of the AEC's Albuquerque Operations Office.

The fire occurred in Building 776–777 (figure 4) which is used for manufacturing plutonium parts. This building is a complex facility which has been rearranged and modified repeatedly over the years to meet changing production requirements and schedules. The equipment in Building 776–777 includes various types of machinery operated in "glovebox" systems (figure 5).

The gloveboxes are under a slight negative pressure with respect to the air in the room around them. Although they are fairly well sealed, air enters the gloveboxes from the room in which they are housed and exits through ducts to filtered systems on the roof. This provides a means for working safely with plutonium while separating the operator from this potentially hazardous radioactive material. Gloveboxes have portholes which are sealed by rubber gloves which workers use to perform operations in the boxes. The gloveboxes used in related system operations are connected by conveyor lines. In turn, the systems are interconnected by other conveyor lines, by which plutonium is transferred from one operation to another. The conveyor lines connecting the gloveboxes are long enclosed tunnels lined with plastic windows. In some areas, thick pieces of either plastic or cellulosic laminate material (made from wood chips) have been placed on the inside or outside of the gloveboxes and conveyor lines as radiation shielding.

The first indication of a fire was an alarm received in the plant's fire station at 2:27 p.m. on May 11 from the heat-sensing system which monitors temperatures at various locations in the glovebox systems in Building 776–777. Although the fire department responded promptly, the dense smoke, crowded conditions, and presence of large

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[1] Summarized from AEC Release No. 257, November 18, 1969.

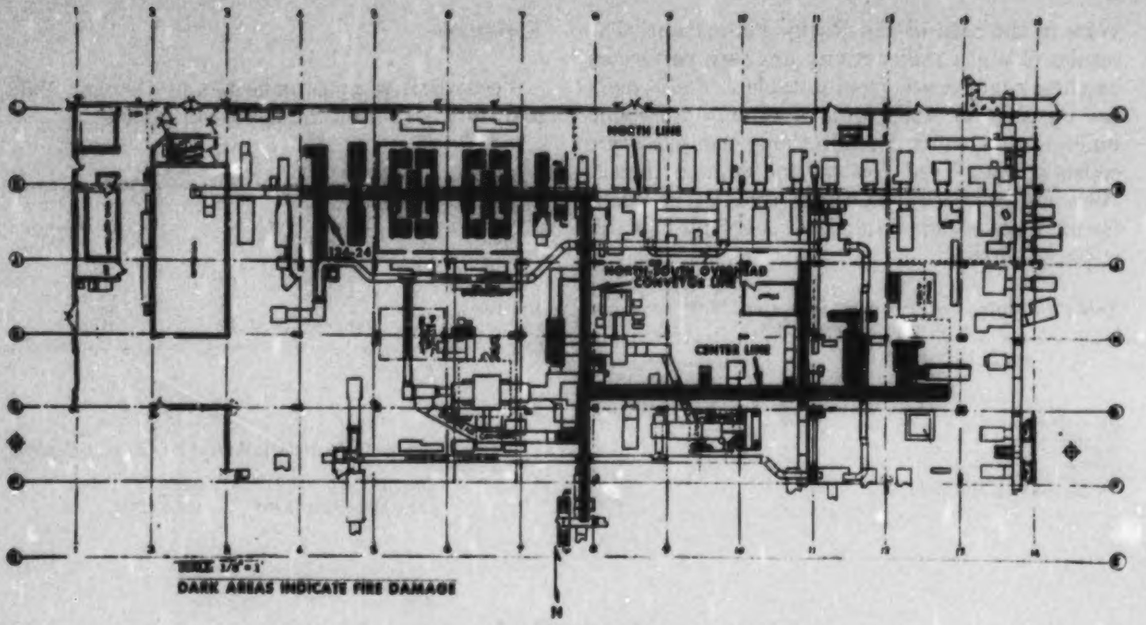
NORTH LINE
134-24
NORTH-SOUTH OVERHEAD CONVEYOR LINE
CENTER LINE
SCALE 1/8"=1'
DARK AREAS INDICATE FIRE DAMAGE
N

Figure 4. Fire damage to building 776, Rocky Flats Plant

quantities of combustible shielding material made the fire very difficult to fight and extinguish. Because of the concern about the possibility of a nuclear criticality accident (a chain reaction), the standard firefighting procedures in effect for Building 776–777 did not specify the use of water except as a last resort. For this reason, there was no automatic sprinkler system in this area of the building. The first attack on the fire was made with CO_2 and was ineffective. Less than 10 minutes after the fire alarm was received, the fire captain initiated the use of water. Thereafter,

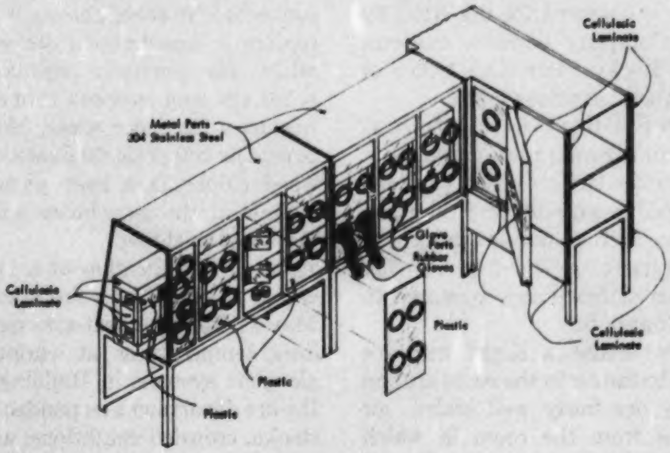
Cellulosic Laminate
Metal Parts 304 Stainless Steel
Glove Ports Rubber Gloves
Cellulosic Laminate
Plastic
Cellulosic Laminate
Plastic
Plastic

Figure 5. Glovebox 134–24

water was used almost exclusively in the firefighting activities. No nuclear criticality occurred. The fire was brought under control about 6:40 p.m., but continued to burn or recur in isolated areas throughout the night.

The fire originated within the north line, moved rapidly through the north–south overhead conveyor line, and subsequently spread through one of the interconnecting conveyors and into the center line. Some plutonium contained in these lines burned, and as the glovebox windows burned out, plutonium oxide was released into the room. (Note: When plutonium metal burns, it converts to the oxide form from which it can again be converted to metal without significant loss of material.) Because of the extensive plutonium contamination and smoke, all personnel entering the area during the fire were required to use self-contained breathing air systems which severely limited both access to, and time in, the fire area. There were no lost time injuries from the fire or the firefighting, although one firefighter inhaled some plutonium most of which was quickly eliminated following treatment.

[illegible]e damage to Building 776–777 and its equipment was extensive. In addition to the actual fire and smoke damage, the building was heavily contaminated internally with plutonium. Substantial parts of the utility systems within the building were severely damaged. Some of the interconnected buildings sustained minor interior contamination. The fire did not breach the building roof, but slight exterior contamination was measured on the roof of Building 776 and an adjoining building, apparently due to a minor failure of a filter. Plutonium also was tracked out of Building 776 by the firefighters and was detectable on the ground around the building. There is no evidence that plutonium was carried beyond the plant boundaries.

The available evidence indicates that the fire originated on the lower shelf of the storage cabinet in glovebox 134–24 in the north line. Plutonium briquettes (discs 3 inches in diameter and 1-inch thick of either pressed scrap metal or lathe turnings) and some loose scrap metal were stored in uncovered cans in the storage cabinet. The exact cause of ignition is unknown; however, plutonium in the form of chips or lathe turnings is a pyrophoric material. The heat from the burning plutonium metal evidently caused the storage cabinet, which was constructed mostly of cellulosic laminate material and plastic, to char and generate flammable gases which could have been ignited by burning plutonium. The heat of the burning gases could ignite other briquettes and initiate a slow burning of the storage cabinet materials, particularly in the cracks between the joined sections of the cellulosic materials.

The smoke in the exhaust system of the north line gradually clogged the filters. Flames erupted on the outer surfaces of the cabinet and spread to the combustible gloves and plastic windows on glovebox 134–24. Up to this time, the fire was still undetected by the few people who were in the building that day because the smoke, flames, and heat were contained within the glovebox system. Since the heat detectors were located outside and under glovebox 134–24 and were insulated by the floor of the storage cabinet, they were incapable of sensing the fire. (Similar detectors elsewhere in the glovebox system subsequently did function, and the alarm was sounded.)

Once the plastic windows of glovebox 134–24 were breached, the inrushing air fanned the fire and caused it to spread into the north conveyor line and the gloveboxes east of glovebox 134–24.

The airflow in the north conveyor line normally goes from east to west. However, because of the clogged filters, the airflow in the line reversed and followed the second ventilation system which is part of the north–south overhead conveyor line and the center line. When the fire reached the north–south line, it turned south because of two factors; a closed metal door in the north line, and the direction of the airflow. On reaching the center line, the fire again went east because of the airflow.

Decontamination, cleanup, and installation of equipment in the fire-damaged building have made possible the resumption of developmental production, even though not yet full scale. About 80 percent of the 211,000 square-foot structure has now been decontaminated.

More than 99 percent of the plutonium that was in the building before the fire has been retrieved. Eventually the AEC expects to reuse essentially all of this plutonium. The balance is combined with other fire debris and will be handled routinely as is other radioactive waste material.

Reported Nuclear Detonations, January 1970

(Includes seismic signals from foreign test areas)

The U.S. Atomic Energy Commission announced that it had conducted two nuclear tests during January 1970.

Both nuclear tests were of low yield (less than 20 kilotons TNT equivalent) and were conducted underground, January 23 and January 30, 1970, by the Atomic Energy Commission at its Nevada Test Site.

On January 29, 1970, the United States recorded seismic signals which originated in the Soviet nuclear test area in the Semipalatinsk region. The signals were equivalent to those of an underground nuclear explosion in the low-intermediate yield range (20–200 kilotons TNT equivalent).

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SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

STRONTIUM-90 AND CESIUM-137 IN TOTAL DIET SAMPLES—A COMPARATIVE STUDY OF DATA: *P. D. Roecklein, C. E. Smedley, and R. E. Simpson. Radiological Health Data and Reports, Vol. 11, February 1970,* pp. 47–64.

Six federal, State, and private organizations have published values for strontium-90 and cesium-137 activities in total diet samples for the period, January 1961 through December 1967. The data reported by these organizations have been statistically compared to determine how well the values of the several agencies agree. Our results show that there is agreement (at a significance level ( ) equal to 0.05) in about 60 percent of the cases for comparable samples collected at about the same location and time and analyzed by similar methods. The 40 percent disagreement may be due to differences in samples, however, the specific sampling sites within a geographical area cannot be verified.

Keywords: Cesium-137, diet, strontium-90.

RADIOLOGICAL HEALTH DATA AND REPORTS

Volume 11, Number 3, March 1970

In August 1969, the President directed the Secretary of Health, Education, and Welfare, to intensify Departmental activities in the field of radiological health. The Department was assigned responsibility within the Executive Branch for the collation, analysis, and interpretation of data on environmental radiation levels such as natural background, radiography, medical and industrial uses of isotopes and x rays, and fallout. The Department delegated this responsibility to the Bureau of Radiological Health, Public Health Service.

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Department of the Interior
Department of Agriculture
Department of Commerce
Department of Health, Education, and Welfare
Atomic Energy Commission

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A DECADE OF PUBLICATION

With this issue, *Radiological Health Data and Reports* marks the completion of ten years of publication. While a ten-year history of publication hardly justifies the issuance of a *festschrift*, it does present a timely opportunity to acknowledge the contributions of the many individuals and agencies whose guidance and efforts helped to establish the publication as an instrument of information on radiation in relation to man's environment. On a more sobering note, the occasion invites an appraisal of past performance and of our responsiveness to changes of emphasis with new directions of public interest.

Radiological Health Data and Reports was established in response to a need to provide information, from a public health-directed source, on levels of radiation to which the population, or population groups, may be exposed. The launching of the publication was given impetus by public concern about the impact of the nuclear age on people's health and well being. Programs that were instituted to assess environmental radioactivity resulting from nuclear weapons tests and other operations involving nuclear energy provided the prime sources of data. In this enterprise, the cooperation of Federal, State, and local governmental agencies, as well as that of various research and educational institutions, played an important role. In particular, grateful acknowledgment is due the Board of Editorial Advisors for its guidance on general policy and their continuing review of content.

Over the years, national concerns in the area of radiological health have undergone changes both in emphasis and scope. As fallout from nuclear testing operations conducted in the 1950's and early 1960's declined, greater emphasis was attached to radioactivity resulting from nuclear power plant and Plowshare program operations. In particular, the importance of machine-produced radiation, especially x rays, received the recognition it deserved. With the passage of Public Law 90–602, the "Radiation Control for Health and Safety Act of 1968," these concerns were extended more widely across the electromagnetic spectrum and even outside the electromagnetic spectrum. As defined in the Act, which relates to electronic product radiation, the term means:

"(A) any ionizing or non-ionizing electromagnetic or particulate radiation, or

"(B) any sonic, infrasonic, or ultrasonic wave, which is emitted from an electronic product as the result of the operation of an electronic circuit in such product . . ."

As information becomes available with respect to the nature and extent of population exposure to such radiation, it is anticipated that reports dealing with the findings will be published in *Radiological Health Data and Reports*. Previous issues have contained reports on emissions of x rays from color television receivers and on the experience of a State following the enactment of a laser registration law. In the current issue, there appear two reports on the results of surveys of x-ray machines and a technical note relating x-ray emissions to the lead content of glass envelopes of color television tubes. The frequency of appearance of reports in these and other areas of electronic products is expected to increase as programs progress.

We look forward to serving the needs of the radiological health community for information in keeping with its broader interests. To the many agencies and individuals whose participation in many capacities made our modest history of publication possible, we offer our deepest thanks. And to all who move with us to meet the future, we express the hope that they will experience the satisfactions that we have enjoyed.

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Results of a Program Directed Toward Reduction of Dental X-ray Exposure

Robert B. Rosenthal and *James C. Malcolm*[1]

X-ray safety surveys in 208 dental offices revealed that almost one million radiographic films were exposed annually. A special study was made of procedural factors affecting roentgen exposure at the cone tip of dental x-ray machines; these were film speed, developing technique, and kilovoltage. Although only 27 percent of the offices were using slow or intermediate speed film, they were found to be responsible for 45 percent of the total cone-tip exposure. A change to faster film reduced their exposure levels by 54 percent. Offices accepting recommended changes in developing technique reduced their exposure levels by 43 percent. The program's effect was an overall exposure reduction of 27 percent. With properly developed fast film, the median exposure levels ranged from 0.19 R/film at 90–100 kVp to 0.62 R/film at 45–55 kVp. The accuracy of electric and electronic timers was also evaluated in selected dental offices.

Special emphasis was placed upon the use of fast film and optimum developing techniques while conducting routine radiation safety surveys of 208 dental offices with 234 x-ray machines, located in two cities in Alameda County, Calif. Data collected on the initial visit provided a projection of almost one million intra-oral films exposed annually, a total cone-tip exposure[2] in the area of 662,000 roentgens per year, averaging approximately 0.67 roentgens per film. This sizeable number of machines offered an opportunity to investigate the relationship of film speed and film processing to cone-tip exposure and a means of finding exposure levels which might be expected at various kilovoltages in offices which develop fast film under near-optimum conditions. It was also decided to record the accuracy of electric and electronic timers.

Methods and standards

All basic information was acquired during actual surveys of the offices and by interview with the dentist or his assisting personnel. All units were properly filtered and collimated[3]. The cone-tip exposure was measured with a Victoreen condenser R-meter and 10-R chamber[4]. For use in the followup stages of the program--when survey time permittedinfor--mation was acquired on roentgens per film at reduced exposure settings, either by establishing timer performance with a spinning top timer or by determining actual exposure values at a variety of timer settings.

A small phantom consisting of two human molars and jawbone encased in paraffin was used to demonstrate that films of high diagnostic quality could be obtained at reduced exposure levels by improvement in exposure and darkroom techniques. When possible, high speed film was demonstrated to users of the slower type film.

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[2] "Cone-tip exposure" refers to the local roentgen exposure in air at the cone tip. The terms "exposure" and "roentgen" bear the same connotation in this report.

[3] As required by the California Radiation Control Regulations, tubes operating up to 70 kVp must have at least 1.5 mm total aluminum equivalent filtration; 2.5 mm is required above 70 kVp. Beam dimension at the cone tip must not exceed 3 inches in diameter. All tubes were found to have circular beams.

[4] In a separate study, it was determined that use of the 10–R chamber with readings in the lower 25 percent of its scale did not introduce any significont error.

Improvement was determined in both of the above parameters by either a followup telephone call or by the use of a reply postcard.

When needed data had not been recorded on the initial visit, a special visit was made if the workload exceeded 75 films per week. The office was excluded from the tabulation when the workloads were small.

In the majority of cases, no followup visit was made to confirm the technique changes reported by the dentist. There is no information on the accuracy of reported improvements or to what degree the new changes were retained. However, in virtually all offices, the dentist accepted the demonstrated improvement as valid.

Film speed

The descriptive term "fast film" refers to Speed Group D, "intermediate" to Speed Group C, and "slow" to Speed Group B-- standards which were established by the ADA Council on Dental Research (*1*). Table 1 is a listing of common brands of film and their several speeds. It is important to note that two intermediate speed films carry the brand description "extra fast."

Table 1. Speeds of common brands of dental film

Manufacturer	Speed of film		
	Slow (speed group B)	Intermediate (speed group C)	Fast (speed group D)
Dupont	D-1		Lightning Fast (LF)
IFI	Blue Hue (BH)	Super Blue Hue (SBH)	Ultra Blue Hue (UBH)
Kodak	Radiatized		Ultra Speed
Minimax		Extra Fast (EF)	Triple X
Rinn	Medium Fast (MF)	Extra Fast (EF)	Super Fast (SF)

Film processing

Processing film according to a specific time-temperature standard is uniformly accepted as the foundation for good diagnostic films. A film is considered to be developed satisfactorily if it is processed at least as long as recommended by the manufacturer for a given temperature. Further exposure reduction is possible by use of "complete" development as shown by the results in table 2 (per manufacturer). The following descriptions are used in discussions:

Sight development	any developing without definite time-temperature relationship.
Under development	any developing time which is shorter than either of the following
Development per manufacturer	based on 4½ minutes at 68°F. (±0.5 minute) or equivalent, with regular dental developer
Complete development	based on 5 minutes at 70°F. (±0.5 minute) its equivalent or longer, with regular dental developer.

Average roentgens per film

In offices using varying exposure times (or varying kVp's in a limited number of cases) it was necessary to establish an average exposure time from which average roentgens per film could be determined. For this value, a correction factor of 0.87 was applied to the roentgen exposure for a mandibular molar. This value is slightly lower than that derived from Wuehrman and Manson-Hing (*2*) and corresponds to that calculated from the following technique for a full mouth survey:

4 molar films, each 0.5 second exposure
4 bicuspid films, each .4 second exposure
4 cuspid films, each .4 second exposure
2 incisor films, each .3 second exposure
4 bitewing films, each .5 second exposure

The average exposure time is 0.43 second, which is the molar exposure multiplied by the 0.87 factor. No factor is applied to offices employing the same exposure technique on all films.

Results

Film speed and patient exposure

The importance of film speed in relation to exposure levels is demonstrated in table 3. Twenty

Table 2. Exposure reduction through improvement in darkroom technique in offices using fast film (all kilovoltages)

Developing technique	Findings on initial visit				Findings on followup inquiry					
	No. of offices	Films per week	R per week	Average R/film	No. of offices	Films per week	Original R/week	Reduced R/week	Total reduction R/week	Average R/film
Sight	45	3,342	2,058	0.62	29	2,375	1,639	879	760	0.37
Underdevelopment	42	4,645	2,868	.62	27	3,196	2,005	1,183	822	.37
Per manufacturer	36	2,720	1,341	.49	22	1,614	794	466	328	.29
Complete	20	3,578	1,045	.29						
Total	143	14,295	7,312		78	7,185	4,438	2,528	1,910	

percent of the offices used slow film, and although these offices used only 16 percent of the total film, they were responsible for 33 percent of the total x-ray exposure. Sixty-nine percent of the offices used fast film (73 percent of all film used) but were responsible for only 55 percent of the total exposure.

Table 3. Film speed and patient exposure as found on initial visit

	Total	Speed group		
		B Slow	C Intermediate	D Fast
Number of offices using this speed film	208	42	23	143
Percent	100	20	11	69
Films per week	19,641	3,263	2,083	14,295
Percent	100	16	11	73
Total cone tip exposure per week (R)	13,249	4,410	1,526	7,312
Percent	100	33	12	55

Trade names of film resulted in a certain amount of confusion; many users of Rinn and Minimax "Extra Fast" film (both are intermediate, or Speed Group C films) were under the impression that they were using fast film (Speed Group D).

Considerable effort was devoted to inducing users of slow and intermediate film to change to fast film. On followup inquiry it was found that of the 65 offices involved, 15 changed as suggested, for a net reduction of 725 roentgens per week or 54 percent of their previous weekly exposure of 1,331 roentgens. Reductions due to improved development procedures are not included in this calculation.

Efforts to encourage change to faster film encountered resistance due both to personal preferences and to mechanical obstacles. Many users of slow film were older practitioners who felt that this film provided the best in diagnostic value. Some stated that they had tried faster film and did not like it, but whether this reaction resulted from inherent characteristics of the film or from improper processing is not known. In some cases, they were using machines (particularly the General Electric Model CDX and CDX–E) that have no milliampere control and have timers that are unable to make accurate split-second exposures. There was considerable resistance to changing to long cone technique as a means of using fast film. The necessary tool for adjustment of the milliamperage on Ritter B units was acquired in the middle of the program, and the milliamperage was reduced on those units where the dentist was willing to make the change but had a timer which could not perform reliably at the short exposure times required by short cone units.

Table 4 indicates that the use of slow film creates unnecessary patient exposure, even when films are developed according to the manufacturer's standards or longer for a given temperature.

In addition to the obvious fact that the required exposure for slow film is four times that for fast film, this table indicates that although only 13 percent of the offices used slow film (and represented only 7 percent of the total film used), they were responsible for over 23 percent of the total exposure.

Table 4. Average roentgens-per-film at cone tip (all kilovoltages) for films in speed groups B and D (developed "per manufacturer" or better)

Speed group	Number of offices	Films per week	Average R per film	Total R per week
B	15	821	1.34	1,100
D	96	10,763	.33	3,558

Film processing and patient exposure

Whereas less than one third of the offices presented an opportunity to reduce exposures through change in film speed, almost 61 percent were sight developing or processing film too quickly for a given temperature. Of this 61 percent, over half were sight developing indicating that the majority was completely unaware of any need for a systematic method of film processing.

Table 2 shows the initial findings and progress made in reducing exposures by darkroom techniques in those offices using fast film. It is to be noted that even offices previously developing according to manufacturer's standards were capable of affecting an additional reduction in exposure by suing complete development techniques.

Replies from 20 offices using slow film (1,158 films per week) showed that improvement in darkroom techniques reduced the average exposure from 2.0 R to 1.8 R per film.

Some offices which showed improvement did not necessarily go to complete development. Therefore, in compiling values for net improvement, the offices were grouped into two categories: (1) those sight developing or underdeveloping, and (2) those developing according to manufacturer's standards or completely.

Table 5 shows the effectiveness of placing emphasis on proper darkroom procedures. Responses from dentists showed a doubling of the use of recommended techniques with a resulting 22 percent reduction in total patient exposure.

Table 5. Effects of the survey program on developing technique and patient exposure (all kilovoltages, all speeds of film)

Survey	Percent of 208 offices developing film as recomended	Percent of 19,641 films/week	Percent of weekly exposure	206 offices total weekly exposure
Initial	37	38	29	13,249
Follow-up	73	76	68	10,291

It is evident that with the use of proper darkroom techniques overall exposure is reduced. A doubling of the number of offices and films in this category more than doubled the group's share of population exposure, but the total weekly exposure was reduced by 22 percent. Improvement in darkroom techniques has proved to be the most productive activity within the program, and should result in a benefit to dentists by providing radiographs of superior quality.

A surprising number of offices had no provision for warm running water in the darkroom, a condition not compatible with good processing because ambient temperatures were often below acceptable levels. Many had no running water at all, a deficiency likely to result in incompletely rinsed films and contaminated fixer. A lack of recognition of the direct relationship between exposure and film processing was evident.

No discussion of developing would be complete without mention of the 1-minute developer. The manufacturer of one brand informed us that the "1 minute at 68°F" equals, in terms of net density, conventional processing for 3 minutes at 68°, and that at 68° it would be necessary to develop for 1½ to 2 minutes with intermittent agitation to be equivalent to 5 minutes at 70° with conventional processing. In order to attain full development within 1 minute, temperatures of 72° to 76° would be necessary which would not be harmful if polyester-base films are used. It was, therefore, decided to rate this procedure as "Underdevelopment" rather than "Per Manufacturer," since the latter classification would be equated with developing for 4½ minutes ±0.5 minute. As an example of what might be expected if developing were "complete", one dentist (included in this report), experimented and found that by changing the development time from 1 minute at 68° to 2½ minutes, he was able to reduce exposures by 30 percent.

Average roentgens per film

In order to establish a base with which to evaluate exposure levels, figure 1 was developed, showing average exposure per film at typical peak kilovolts (kVp) in offices developing Speed Group D film according to manufacturer's standards or longer for a given temperature.

This report does not discuss exposure to areas of the body or head other than that measurable directly under field conditions--the skin of the patient in air at the cone tip--and no effort is made to calculate an integrated dose. The purposes were: 1. to record levels of the exposure in air as found; 2. to indicate the degree to which these exposures can be reduced through the use of fast film and proper darkroom film processing; and, 3. to suggest exposure levels at various kVp's acceptable when fast film is properly processed.

Any decrease in exposure will reduce the absorbed dose to critical organs which, in the case

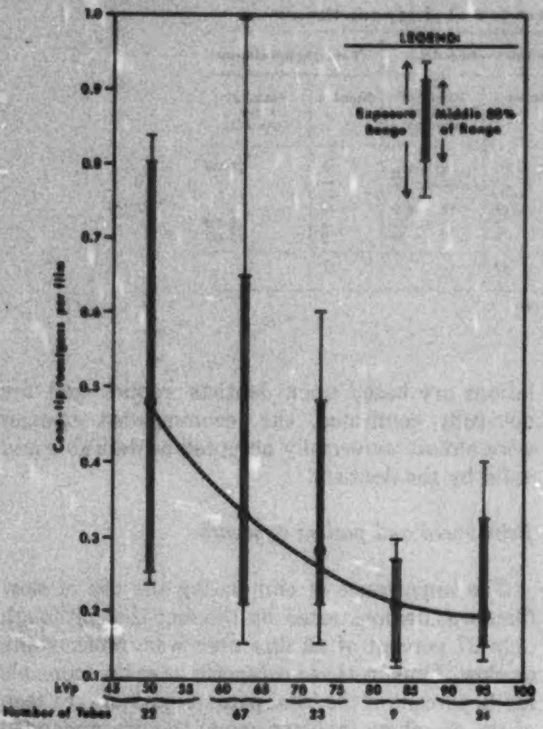

Figure 1. Cone-tip roentgens per film at various kVp levels in offices using fast film and developing at manufacturer's standards or better

of dental roentgenography, are the lens of the eye and the thyroid gland. Persons interested in absorbed doses are referred to Richards and Webber (*3*), who report exposures to those areas ranging from 0.8 percent to 2.6 percent of the total exposure. Focht et al. (*4*) report exposure to the eye to range from 10 mrem for a single lower bicuspid x-ray exposure to 1,000 mrem for an upper bicuspid. The gonadal exposure to the patient is extremely low in properly conducted dental x-ray procedures (*5–6*). Kline et al. (*7*) reports the male gonadal exposure (measured with thermoluminescent dosimeters) to be 0.39 mR per 10,000 mR of direct-beam exposure at the cone tip at 65 kVp, and 0.66 mR per 10,000 mR at 90 kVp. If the patient were draped with a leaded apron, or a lead-lined open cone were used, exposures would be even less.

The reduction in exposure per film with increasing kilovoltage is obvious, but this is not the complete picture. Richards and Webber (*3*) state that with 90 kVp the tissues lying shallower than the film depth receive smaller doses, while the tissues lying deeper receive greater doses than when a lower energy beam (65 kVp) is used; the exit dose is higher at increased kVp.

The excessively wide range of exposure levels shown in figure 1 suggests that while some dentists are diagnosing from films which are rather lightly exposed, a significant number are demanding films with densities which are unnecessarily high.

A final comparison, probably the most dramatic demonstration of the effectiveness of the program, is shown in figure 2. Instead of being limited to the 234 x-ray machines discussed so far, it represents 395 x-ray machines throughout the county. The additional 161 tubes were located during the continuing survey program, the results of which are not otherwise included in this report.

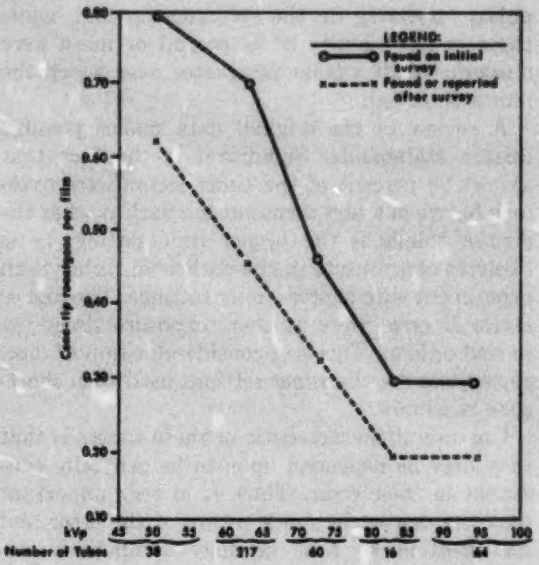

Figure 2. Mean cone-tip roentgens per film before and after survey (all film speeds, all developing techniques)

Electric and electronic timers

Timer accuracy is mentioned because the dentist, while aware of inaccuracies inherent in mechanical timers, is likely to assume that an electric or electronic timer is accurate. Unfortunately, this expected accuracy is not necessarily assured.

Table 6. Range of error in electric and electronic timers

Manufacturer	Number of timers	Timers accurate ± 10 percent	Timers overexposing		Timers underexposing	
			Number	Range of error (percent)	Number	Range of error (percent)
A	23	11	10	12½–100	2	17–33
B	30	12	18	12½– 67	—	
C	8[a]	8	—		—	
D	14	—	14	17 –400	—	
E	7	3	1	25	3	14–70
F	14	6	6	12 – 20	2	20–65
Total	96	40	49		7	

[a] This model is clearly identifiable as an impulse timer.

Table 6 shows findings on commonly encountered equipment based upon tests made with a spinning top timer on the majority of units equipped with an electric or electronic timer. Reproducibility was not checked on all units. Short exposure times were measured by actual count of the 60-cycle pulses appearing on the spinning-top film, while those in the vicinity of ¾ second or more were measured with a polar protractor over which the film was placed.

A review of the original data makes possible certain statements. Significant is the fact that almost 90 percent of the timer errors were overlong for when a film turns out too dark at what the dentist thinks is the proper time setting, he is likely to compensate in the darkroom rather than experiment with shorter timer settings. The higher levels of error were at short exposure times (¼ second or less). This is of considerable importance, since these are the timer settings used with short-cone machines.

One useful characteristic of these timers is that they may be depended upon to be generally consistent in their error. Thus, it is very important that the dentist be made aware of the error and its direction so that he may compensate accordingly.

Summary

In the course of making radiation safety surveys in 208 dental offices, using 234 x-ray tubes, in Oakland and Alameda and the county of Alameda, Calif., special emphasis was placed upon the use of fast film and proper processing of film. The total reduction in x-ray exposure resulting from these efforts was approximately 27 percent of the total original exposure. Although, the calculations are based upon dentists' replies and are not fully confirmed, the recommended changes were almost universally accepted as desirable and valid by the dentists.

Film speed and patient exposure

The importance of eliminating the use of slow films was demonstrated by the fact that although only 27 percent of all film used was intermediate or slow, films in those categories were responsible for 45 percent of the total patient exposure. Fifteen of the 65 offices involved made the recommended change, resulting in a 54 percent net reduction of their total exposure. Much effort remains to be directed in this area

Film processing and patient exposure

This portion of the program was clearly effective. As a result of the surveys, the number of offices developing film in an acceptable manner doubled with a reduction of 43 percent in exposure in those offices, and an overall exposure reduction of 22 percent. Darkroom procedures will be checked carefully on future visits, for it is likely that some offices will tend to revert to former careless habits in the darkroom.

Average roentgens per film

When fast film is developed properly, one may anticipate cone-tip exposures ranging from 0.62 roentgen per film at 45–55 kVp to 0.19 roentgen per film at 90–100 kVp. The range of exposure levels within the kVp groups is quite wide, suggesting that some dentists are demanding film density far above that required for good diagnosis.

Electric and electronic timers

Electric and electronic timers generally repeat accurately at any given exposure setting, but the actual exposure time may not agree with the dial setting. Of 96 units tested, only 40, mostly the newest models, were found to be accurate within ±10 percent. Most mechanical timers cannot repeat accurately any exposure times which would be required for good techniques with a short cone.

Recommendations

It may be assumed that in the future it will not be necessary to correct physical aspects of dental x-ray machines such as filtration and collimation. Therefore, it appears that the continuing program of resurveys will be most productive by emphasizing use of fast film and maximum developing techniques. Seventy-seven percent of the offices using slower films had not changed to fast film at the time of this report. Although the percentage of offices still approachable on film processing is less, a considerable amount of patient exposure couls still be reduced, and some backsliding in "improved" offices is anticipated. Even those offices developing according to manufacturer's standards should be encouraged to adopt the "maximum" technique, as evidenced by table 2.

In discussing film speeds with dentists, it is strongly recommended that the American National Standards Institute speed designation be routinely used in conjunction with any brand names which might be discussed. This would minimize the confusion between Speed Group D films and other films with fast-sounding names which are actually in the slower Group C.

Acknowledgments

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REFERENCES

(*1*) COUNCIL ON DENTAL RESEARCH. Council adopts American Standard speed classifications for intraoral dental radiographic film: diagnostic grade. J Amer Dent Ass 65:280–283 (1962).
(*2*) WUEHRMAN, A. H. and L. R. MANSON–HING. Dental Radiology. C. V. Mosby Company, St. Louis (1965) p. 75.
(*3*) RICHARDS, A. and R. L. WEBBER. Dental x-ray exposures of sites within the head and neck. Oral Surg:754 (December 1964).
(*4*) FOCHT, E. F., G. R. MERRIAM, and J. A. EVANS. Dose to the eye from radiographic exposures. Radiology 76:459–463 (March 1961).
(*5*) ANON (no date). Appendix 21 to 1966 Congressional Hearings on Proposed Legislation Relating to Uniform Record Keeping and Workmen's Compensation Coverage for Radiation Workers. Table 1, footnote 12, p. 819.
(*6*) RICHARDS, A. G. Gonadal irradiation of dental patients. J Amer Dent Ass 65:1–11 (July 1962).
(*7*) KLINE. A. B., JR., H. F. STEWART, W. WELLOCK, and A. MAITLAND. Dosimetric evaluation of 30 dental facilities in Massachusetts: Measurement of workload related to exposure to environs. Oral Surg Med Pathology 29:44–58 (January 1970).

Survey Results of the Use of X Rays in the Healing Arts Specialties in North Dakota, 1964–1968

James A. Kraeger and *Gene A. Christianson*[1]

The x-ray facilities of all healing arts specialties (except dentistry) in North Dakota were surveyed by the State Department of Health to determine the degree of compliance of the x-ray facilities with the recommendations published in NBS Handbook 76. An average of 8,529 patients is radiographed per week in the healing arts specialties in North Dakota, for a total of 443,508 patients radiographed per year. Hospitals and multiple-specialty clinics account for 81 percent of the radiographs. An average of 881 patients receives a fluoroscopic examination each week for a total of 45,812 examinations per year. Of this fluoroscopic workload, 88 percent are conducted in hospitals and multiple-specialty clinics. Fifty-eight percent of the diagnostic x-ray machines were found to be deficient upon initial evaluation. The majority of deficiencies were inadequate collimation and/or inadequate filtration of the useful x-ray beam. Major deficiencies resulting in an unnecessary genetically significant dose were found to exist in facilities that expose 195,676 persons annually. Forty-nine percent of the individuals operating x-ray equipment in North Dakota are not registered with the American Registry of Radiologic Technologists. Of the non-registered technicians, 76 percent had less than a year of x-ray training and 74 percent indicated that aspects of x-ray protection were not included in their training.

During the past 40 years, with the growth of diagnostic applications of x ray, increasing attention has been directed toward the possible effects of lower levels of radiation on present and future generations as well as to the somatic effects. In recognition of these effects, various scientific bodies have made recommendations to limit the irradiation of the human body (*1*). Between 1931 and 1960, the recommended American exposure limit was reduced from 0.2 rem per day to 5 rem per year for occupationally exposed individuals and 0.5 rem per year for non-occupationally exposed individuals (*2*, *3*).

A conservative assumption is that the somatic and genetic effects resulting from radiation exposure have no threshold and that a direct linear relationship exists between dose and biological response. This concept is based on firm evidence as to the effects of heavy dosages and the lack of evidence that low dosages do not produce biological effects (*1*). Thus, the basic philosophy of the Radiological Health Program of the North Dakota State Department of Health emerges as "obtaining the maximum benefit from the use of radiation with least human radiation exposure". The activities of the program focus upon the reduction of human exposure to radiation by practical methods, thereby enhancing the beneficial applications of radiation.

In the spring of 1964, the Radiological Health Program initiated the voluntary physical survey of the x-ray facilities of all healing arts specialties. For purposes of this discussion, the healing arts specialties are defined as hospitals, multiple-specialty clinics, general practitioners (private offices), chiropractors, osteopaths, chiropodists, and radiologists. The use of x ray in the healing arts specialties has received the most program attention since they represent the most prevalent source of x-radiation exposure to the largest segment of this State's population. It is this area in which the greatest results can presently be achieved in regard to radiation protection.

The principal purpose of the survey was to determine, by comprehensive evaluation, the degree of compliance of x-ray facilities with the recommendations established by the National Council on Radiation Protection and Measurements (NCRP) as published in "Handbook 76" of the

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National Bureau of Standards (3). These evaluations have been updated in accordance with the new and modified recommendations issued through the NCRP Report No. 33 (4).

Additional objectives of the survey were to:

1. reduce the patient and operator exposure without decreasing the benefits derived from the use of x rays,
2. establish criteria for future resurveys of this type in North Dakota.

The comprehensive evaluation of x-ray facilities includes radiation measurements to determine the radiation exposure of the operator, patient, and people outside the immediate x-ray area; the acceptability of x-ray equipment based on current standards; the evaluation of other portions of the x-ray facility necessary to its operation (film development processes and monitoring record systems); and a discussion with the operating staff on the areas which need attention and those which could eliminate unnecessary radiation exposure. Because of economics and for uniformity for national data recall, the U. S. Public Health Service x-ray protection survey forms were utilized. To accelerate the recall of this information, the data from the survey forms were transferred to automatic data processing cards. The information of interest was obtained through the use of a card sorter.

The information collected in the evaluation of 364 x-ray machines used by the healing arts specialties in North Dakota is presented in the tables and discussions below. By the end of 1968, 97 percent of the x-ray machines registered with the State Department of Health had received the initial evaluation.

An average of 8,529 patients were radiographed per week in the healing arts specialties, for a total of 443,508 patients radiographed per year. Eighty-one percent of the patients were radiographed in hospitals and multiple-specialty clinics. A low estimate would be an "average" of two exposures per patient or a total of 887,016 radiographic exposures per year. This estimate does not include spot films associated with fluoroscopy. An average of 881 patients were fluoroscoped per week for a total of 45,812 patients fluoroscoped per year. Of these patients, 88 percent were fluoroscoped in hospitals and multiple-specialty clinics.

Radiographic units

Personnel, workload and equipment

Fifty-three percent of the healing art specialties never used a personnel monitoring system (table 1). The x-ray machines of the healing arts specialties were operated by 477 individuals of whom 45.5 percent were not monitored. In many instances, because the workload was minimal and the location of the operator was adequate, it was calculated that the operator in his normal functions would not receive an exposure exceeding one-fourth of the applicable maximum permissible dose (MPD) in any calendar quarter. Additionally, many of the operators were physicians who declined to monitor themselves. This was found to be especially true for the general practitioners and chiropractors. Whenever it appeared that the operator's exposure could exceed 25 percent of the applicable MPD, it was suggested that a monitoring system be instituted.

In one instance, the monitoring system of the facility was rated inadequate because the x-ray operator was not covered by the monitoring service, and in another instance the adequacy of the monitoring system was not determined because the records were unavailable at the time of the survey. Ten monitoring record systems were inadequate because complete up-to-date records of exposure for each occupationally exposed individual were not being maintained.

Personnel monitoring systems were employed in 47 percent of the x-ray facilities. In all instances, the monitoring device employed was the film badge. The monitoring records of 36 individuals in these facilities indicated they had received 300 mR for one or more quarters. The maximum quarterly dose reported was 2.7 rem.

Occupational exposures

As indicated in table 2, several improper procedures are believed to lead to these increased film badge exposures. Due to numerous instances of improper utilization of the film badges, it is difficult to determine whether these dose equivalent values indicated unnecessary exposures. The most frequently recuring improper procedures are:

1. The film badge used to estimate whole body exposure was worn on the outside of the lead

Table 1. Facility information from x-ray protection survey of healing art specialties in North Dakota

Facility information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of facilities	66	50	37	46	4	3	3	2
Personnel:								
Number of personnel occupationally exposed	297	110	141	83	9	4	4	3
Number of x-ray machine operators	231	74	106	53	4	4	3	3
Number of personnel monitored	158	19	104	2	6	4	0	0
Number over 300 mR/quarter	23	1	11	0	1	0	(a)	(a)
Workload: (Average number of patients per week)								
Radiographed	4,135	867	2,920	249	181	181	5	6
Fluoroscoped	469	33	207	4	75	0	1	0
Equipment:								
Number of x-ray machines	186	33	60	46	5	3	2	2
Number of x-ray tubes	244	65	91	47	8	3	3	2

[a] Undetermined—no personnel monitoring system employed.

Table 2. Range of documented dose-equivalent values for occupationally exposed individuals[a] and probable procedures leading to the increased exposures reported

Profession	Maximum mR/month	>300 mR/quarter	Dose equivalent value for year[a] (rem)	Probable procedures leading to increased exposure
Urologist	2,740	Monitoring system discontinued	Monitoring system discontinued	Remaining in close proximity to x-ray tube during activation without wearing protective apparel.
Cardiologist	710	Transferred		Same as above.
Radiologist	310			Undetermined
Radiologist	881	Averaged over 300 mR for 3 quarters	1.300	Undetermined
Radiologic technologist	1,285		6.101	Wearing film badge on outside of protective apparel.
Neurosurgeons (2)			1.0 2.3	Same as above.
Radiologic technologist	1,120		1.434	Wearing film badge on outside of protective apparel. Supporting patients during radiographic procedures.
Radiologic technologist	307		0.876	Failure to wear lead apron while using mobile x-ray units.
Radiologic technologist (3)	400		1.3 1.6 1.7	Same as above.
Radiologist	310		1.9	Undetermined
Radiologist	720		2.3	Undetermined
Technician	420			Manually operating bucky grid during tube activation.
Technician	640		0.049	Failure to remain within the shielded control station during radiography.
Radiologic technologist	765		1.5	Wearing film badge on outside of protective apparel. Supporting patients during radiography.
Radiologic technologist	766		0.766	Undetermined

[a] As reported on the occupational radiation exposure report form by the film badge service contractor.

apron, thus indicating the exposure only to the protective apparel. It was common practice for the fluoroscopist to wear only one badge. It is recognized there is no standardized procedure for the location of a monitoring device and in the interpretation of its reading. It was routinely recommended during the survey that the film badge be worn beneath the protective apron. If there was concern regarding exposure to the extremities, the use of an extremity badge was recommended. In addition, leaving the personnel monitoring badges and the control badge in the x-ray area contributed to an erroneous recorded dose equivalent value.

2. Occupationally exposed individuals supported patients during radiography without wearing appropriate protective apparel such as a protective apron.

3. Occupationally exposed individuals used mobile radiographic equipment without consideration of proper techniques in radiation protection such as distance and protective apparel.

4. Occupationally exposed individuals did not utilize the protective barrier that was provided for them.

One of the healing arts specialties that presents a cause for concern regarding increased exposures is the urologist. The x-ray facilities of urologists at 17 hospitals and multiple-specialty clinics were evaluated where the urologist performed retrograde pyelograms, cystograms, and kidney, ureter, and bladder examinations. Because of the techniques associated with these examinations (the injection of radiopaque dye by the urologist), it was necessary for the urologist to remain close to the patient during x-ray tube activation. The reasons for concern follow:

1. Only 12 percent of the facilities included the urologist under the radiation monitoring system.

2. Only 12 percent of the urologists wore protective apparel during the examination.

3. There were 20 cystoscopy x-ray machines surveyed. Of these, 40 percent displayed inadequate collimation and 25 percent of the beam diameters were large enough to expose infants to total body radiation from the primary beam. The scattered radiation to the urologist was also increased due to the inadequate collimation.

Darkroom procedures

Darkroom procedures employed in the x-ray facilities ranged from no darkrooms to the use of automatic film processors (table 3). The hospital which does not possess a darkroom utilizes the darkroom of an adjoining medical clinic. The radiographic workload of this particular hospital is less than one radiograph per week as only one mobile x-ray unit is employed. As might be expected, automatic film processors were employed only in facilities with sufficient workload to justify the expense of these units.

It is interesting to note that 13 percent of the facilities did not employ a temperature or time-measuring device in the darkroom. This is an area which was stressed in the x-ray protection surveys. Film processing is as important as the techniques involved in positioning the patient for the radiograph. A poorly developed radiograph could necessitate re-examination, thus re-exposing the patient. Both a timer and a temperature indicator must be employed in the tank development of x-ray films. The time-temperature relationships of the development process are not of an arbitrary nature. They provide the criteria for obtaining the best quality radiograph.

Sight development is highest in those facilities (general practitioners in private offices and chiropractors) which also do not employ time and temperature control in tank development. Only 10 percent of the facilities employed sight development. Sight development of x-ray films is not considered good technique as it demands more attention and greater judgment on the part of the person developing the film than following the simple time-temperature recommendations of the developer manufacturer. In the course of facility evaluations, some of the inherent drawbacks involved in sight development were enumerated,

Table 3. Facility information from x-ray protection survey of healing art specialties in North Dakota

Facility information *Darkroom procedures*	Type of facility or type of practice							
	Hospitals	General practitioners in Private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of facilities	66	50	37	46	4	3	3	2
Light-tightness of darkroom:								
No darkroom	1	0	0	2	0	0	0	0
Light-tight	40	33	32	29	4	3	3	2
Not light-tight	25	17	5	14	0	0	0	0
Undetermined	0	0	0	1	0	0	0	0
Automatic processing used:								
Yes	12	0	8	0	3	2	0	0
No	54	50	29	46	1	1	3	2
Thermometer present:								
Yes	46	37	22	33	1	1	2	1
No	3	9	3	13	0	0	1	1
Thermostatically controlled	17	4	12	0	3	2	0	0
Timer present:								
Yes	60	43	37	33	4	3	1	2
No	6	7	0	13	0	0	2	0
Sight development	4	5	0	11	0	0	1	0

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Table 4. Radiographic information from x-ray protection survey of healing art specialties in North Dakota

Radiographic information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of x-ray machines with radiographic capability	172	51	56	46	5	3	3	2
Combination (radiographic-fluoroscopic capability):								
Yes	71	43	36	10	5	0	2	0
No	101	8	20	36	0	3	1	2
Type of x-ray machine:								
Fixed radiographic	99	47	53	46	5	3	2	1
Mobile	73	4	3	0	0	0	1	1
Total filtration at beginning of survey: (mm of AL equiv.)								
<1.5	20	15	5	10	0	0	0	0
1.5–2.4	17	10	7	14	0	0	0	0
≥2.5	123	25	43	21	5	3	2	0
Undetermined	3	1	1	1	0	0	1	2
Total filtration at end of survey: (mm of AL equiv.)								
<1.5	9	3	0	1	0	0	0	0
1.5–2.4	8	2	2	0	0	0	0	0
≥2.5	152	45	53	44	5	3	2	0
Undetermined	3	1	1	1	0	0	1	2
Collimation:								
Proper	20	6	7	18	0	0	1	1
Improper	54	40	14	22	0	1	1	1
Variable	91	5	34	5	5	2	0	0
Undetermined	7	0	1	1	0	0	1	0

including variations in eye sensitivity, low light intensities within the darkroom, and the opacity of the uncleared film.

Filtration and collimation

The importance of proper x-ray beam collimation and filtration in reducing the average significant genetic dose to the population from diagnostic x ray is well documented (*5*). Obtaining proper collimation of the x-ray beam reduces the exposure to the patient, reduces the scattered radiation to the operator and improves the contrast of the recorded image on the radiographic film. Filtration removes the less penetrating useless component of the diagnostic x-ray beam.

A total of 93 percent of the x-ray machines with radiographic capabilities were surveyed (table 4). Due to remodeling of x-ray facilities or dismantlement of the x-ray machine, 7 percent of the x-ray machines were not surveyed. This accounts for the difference between the total number of x-ray machines enumerated in table 1 and the number of x-ray machines in table 4. Evaluation of adequacy or inadequacy of filtration was based on the recommendation of NBS Handbook 76 (*3*).

Of the 338 x-ray machines surveyed, less than 2 percent had a maximum rated kVp below 70. The maximum rated kVp was undetermined on less than 4 percent of the x-ray machines. These were older machines on which "lettered" dial indicators were used in place of kVp direct-reading dial indicators. On the bases of the criteria used, 32 percent of the x-ray machines were being operated with inadequate filtration.

An average of 2,163 patients per week were found to be radiographed by equipment with inadequate filtration. In essence, 25 percent of the patients receiving diagnostic x-ray examinations were being exposed to unnecessary radiation. No attempt was made to determine what dose significance could be applied to this major equipment deficiency. As a corrective procedure of the x-ray evaluation, filters were provided for 77 percent of the x-ray machines to the benefit of 1,692 patients. These x-ray machines will be evaluated on revisits to see if the filtration has been installed.

It is not always possible to determine the amount of added or built-in filtration without disassembling portions of the tube head and/or collimator. It is the policy of the North Dakota State Department of Health not to dismantle any portion of the x-ray machine. If the added or built-in filtration was not visible, the x-ray service and sales representatives were contacted for this information.

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Forty percent of the x-ray machines displayed a primary x-ray beam larger than the area of clinical interest for one or more examinations. The area of clinical interest is defined by the dimensions of the film used for the examination. Radiation exposure of body parts not seen by a film was deemed unnecessary. An average of 1,584 patients per week were radiographed by equipment exposing patients to the primary beam beyond the area of clinical interest. The equipment exposing 45 percent of the patients to inadequate filtration also subjected them to the additional exposure resulting from improper collimation. No attempt was made in this survey to determine what dose significance could be applied to these combined major deficiencies.

Machines with excessive beam sizes were reported in 49 and 78 percent of chiropractors and general practitioners in private offices, respectively; whereas, for hospitals and multiple-specialty clinics, the respective percentages were 33 and 26. There is a direct relationship between the use of variable collimators and proper collimation. The increased usage of variable collimation in the hospitals and multiple-specialty clinics resulted in a lower percentage of improper collimation. This is in good agreement with national trends as reported by the Bureau of Radiological Health, Public Health Service (*6*). Providing equipment with variable collimators is commendable; however, improper use or misalignment of the collimator can negate its value. In several instances, a variable collimator was on the equipment but was improperly used or not used at all. In 4 percent of the facilities, the improper cone was being used when a proper cone was available.

The range of improper collimation extended from three times the diagonal dimension of a 14 by 17-inch film to excess constriction of the beam diameter resulting in image loss (cone cutting) on the radiograph. Furthermore, protective devices (gonadal shields) were not employed during radiographic procedures conducted with 66 percent of the x-ray machines possessing improper collimation.

Operator and environ protection

Based upon scatter radiation measurements, the estimated workload, and the direction of the primary x-ray beam, operator protection, when provided, was found to be adequate throughout this survey. Although the maximum permissible exposure dose was not exceeded, in most instances, the radiation exposure of these individuals could be reduced by a simple change in procedure.

The radiation exposure dose rates observed in the environs surrounding the x-ray facilities were all well within 10 mR per week; in the majority of the smaller x-ray facilities, no additional shielding was provided other than structural materials. The workloads of these facilities did not indicate the need for additional shielding. In 2 percent of the facilities there was insufficient shielding to protect individuals in uncontrolled areas from the primary x-ray beam. In all cases, the primary beam was directed toward a wall-hung chest cassette. In 80 percent of these facilities, the proper use of a cone or collimator would have significantly reduced the area requiring primary shielding.

Fluoroscopic units

Seventy-seven percent of the x-ray machines with fluoroscopic capability surveyed were in hospitals and multiple-specialty clinics. Only 5 percent of the x-ray machines were not of the tilting-table type. Twenty image-intensifying devices were in use during the initial survey program. These devices were in use in 18 percent of the hospitals and 22 percent of the multiple-specialty clinics.

Fluoroscopic screens and target-to-panel distance

The interlocking of the fluoroscopic screen with the x-ray tube and the adequacy of the leaded viewing screens were not found to be a major x-ray protection problem during the initial surveys. Adequate attenuation of the primary beam by the screen was found to be satisfactory in 85.6 percent of the x-ray machines surveyed (table 5).

The relationship between the high percentage of machines (52 percent) in which the primary x-ray beam is not limited to the fluoroscopic screen and the low percentage of machines (7 percent) with improperly functioning shutters is explained by that fact that to be considered improperly functioning, the shutters must fail to operate or must operate erratically. Therefore the shutters could function properly but be improperly adjusted, thus allowing the spread of the primary x-ray beam beyond the fluoroscopic screen.

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Table 5. Fluoroscopic information from x-ray protection surveys of healing art specialties in North Dakota

Fluoroscopic information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of x-ray machines with fluoroscopic capabilitiy	72	20	25	4	4	0	1	0
Fluoroscopic screen ganged to x-ray tube:								
Yes	70	20	25	4	4	0	1	0
No	0	0	0	0	0	0	0	0
Undetermined	2	0	0	0	0	0	0	0
Shutter functioning:								
Properly	63	12	22	3	4	0	1	0
Improperly	2	4	2	1	0	0	0	0
Undetermined	7	4	1	0	0	0	0	0
Useful beam limited to screen:								
Yes	33	5	5	2	3	0	1	0
No	33	11	19	2	1	0	0	0
Undetermined	6	4	1	0	0	0	0	0
Leaded screen:								
Satisfactory	60	16	24	4	3	0	1	0
Not satisfactory	0	0	0	0	0	0	0	0
Not applicable	5	0	0	0	1	0	0	0
Undetermined	7	4	1	0	0	0	0	0
Target-to-panel distance (inches):								
<12	0	0	0	0	0	0	0	0
12–14	3	7	2	0	0	0	0	0
15–17	25	10	12	1	2	0	1	0
18–20	37	2	11	3	2	0	0	0
≥21	2	0	0	0	0	0	0	0
Undetermined	5	1	0	0	0	0	0	0

The target-to-panel distance for all the machines surveyed met the recommendation (not less than 12 inches) in NBS Handbook 76. In fact, 86 percent of the machines had a target-to-panel distance of at least 15 inches. This distance complies with the revised design recommendation as described in NCRP Report No. 33 (4).

Filtration and roentgen output at the panel surface

Of the 126 fluoroscopic machines surveyed, 16 percent were being operated with inadequate filtration (table 6). An average of 21 examinations per week was being performed on the fluoroscopic machines with inadequate filtration, with no examinations being performed on six machines.

Table 6. Fluoroscopic information from x-ray protection survey of healing art specialties in North Dakota

Fluoroscopic information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of x-ray machines with fluoroscopic capability	72	20	25	4	4	0	1	0
Total filtration at beginning of survey (mm of Al. equiv.)								
<1.5	3	3	0	1	0	0	0	0
1.5–2.4	5	3	1	2	0	0	0	0
≥2.5	58	10	23	1	4	0	1	0
Undetermined	6	4	1	0	0	0	0	0
Total filtration at end of survey (mm of Al. equiv.)								
<1.5	2	1	0	1	0	0	0	0
1.5–2.4	4	0	0	2	0	0	0	0
≥2.5	60	15	24	1	4	0	0	0
Undetermined	6	4	1	0	0	0	1	0
Roentgen output at panel surface: (R/min)								
<1	4	0	2	0	0	0	0	0
1.0–4.9	36	7	16	1	3	0	1	0
5.0–9.9	24	5	6	1	1	0	0	0
10.0–14.9	1	1	0	1	0	0	0	0
15.0–19.9	1	1	0	0	0	0	0	0
≥20.0	0	0	0	1	0	0	0	0
Undetermined	6	6	1	0	0	0	0	0

During the survey, filters were provided for eight x-ray machines.

Less than 6 percent of the machines surveyed exceeded the 10 roentgens-per-minute panel surface exposure rate for routine fluoroscopy. An average of five examinations per week was performed on the x-ray machines exhibiting an exposure rate of greater than 10 R/min. On two of the x-ray machines no examinations were performed. Sixty-one percent of the machines exhibited an exposure rate measurement of less than 5.0 roentgens per minute. This would indicate that the performance standards described in NCRP Report No. 33-- that fluoroscopic machines produce exposure rates of less than 5 R/min at the table top-- can be implemented with modern equipment (4).

Accessory shielding

Lead gloves and lead aprons for use with fluoroscopy were found in over 94 percent of the facilities surveyed (table 7). On the other hand, the availability and use of a bucky grid slot cover and lead drapes were found in only 52 and 24 percent of the facilities. In part, the absence of the bucky grid slot cover and lead drapes reflects the age of the equipment. However, several physicians indicated that the bucky grid slot cover, if not fitted properly, interfered with the spot film radiograph. (The image of the bucky grid slot cover was recorded on the radiograph.) In addition, it was reported that the lead drapes interfered with patient manipulation and therefore added to the length of the fluoroscopic examination.

Timer information and light-tightness of fluoroscopic room

Of all the healing arts specialties surveyed, 91 percent used the deadman type of exposure switch on their fluoroscopic x-ray unit (table 8). In one facility, the deadman type exposure switch was altered, maintaining the circuit-closing contact without continuous pressure on the switch.

Of the total fluoroscopes evaluated, 58.5 percent were not equipped with manually reset cumulative timers. While the timer does not insure safe operation, it is of value to the physician as a means for gauging the passage of time. Since this timer can be an expensive addition to old equipment and can be demonstrated by the physician, another means of determining the duration of tube activation the manually reset cumulative timer does not have to be obtained for older equipment.

Of the facilities employing conventional fluoroscopic equipment, 59 percent lacked light-tight fluoroscopic rooms. Extraneous light can interfere with the fluoroscopic examination. Inasmuch as darkening the fluoroscopic room presents no real problem, this item could be easily corrected. Upon resurvey, this item will be re-evaluated.

Table 7. Fluoroscopic information from x-ray protection surveys of healing art specialties in North Dakota

Fluoroscopic information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of x-ray machines with fluoroscopic capabilitiy	72	20	25	4	4	0	1	0
Leaded gloves:								
Yes	67	10	24	2	4	0	1	0
No	3	1	1	2	0	0	0	0
Undetermined	2	0	0	0	0	0	0	0
Leaded apron:								
Yes	68	17	25	4	4	0	1	0
No	3	3	0	0	0	0	0	0
Undetermined	1	0	0	0	0	0	0	0
Bucky slot cover:								
Yes	42	5	15	0	3	0	0	0
No	25	14	10	3	1	0	0	0
Not applicable	3	1	0	1	0	0	1	0
Undetermined	2	0	0	0	0	0	0	0
Leaded drapes around screen:								
Yes	23	1	4	0	2	0	0	0
No	46	19	21	3	1	0	1	0
Not applicable	1	0	0	1	1	0	0	0
Undetermined	2	0	0	0	0	0	0	0

Table 8. Fluoroscopic information from x-ray protection surveys of healing art specialties in North Dakota

Fluoroscopic information	Type of facility or type of practice							
	Hospitals	General practitioners in private offices	Multiple specialty clinics	Chiropractors	Radiologists	Orthopedists	Osteopaths	Chiropodists
Number of x-ray machines with fluoroscopic capability	72	20	25	4	4	0	1	0
Deadman type of exposure switch:								
Yes	70	20	25	3	4	0	1	0
No	0	0	0	1	0	0	0	0
Undetermined	2	0	0	0	0	0	0	0
Manually reset cumulative timer:								
Yes	39	1	8	1	2	0	0	0
No	30	19	17	3	2	0	1	0
Undetermined	3	0	0	0	0	0	0	0
Cumulative timer terminates exposure:								
Yes	35	1	8	1	2	0	0	0
No	30	19	17	3	2	0	1	0
Undetermined	7	0	0	0	0	0	0	0
Light-tightness of fluoroscopic room:								
Light-tight	22	9	9	1	1	0	1	0
Not light-tight	41	10	10	2	0	0	0	0
Not applicable	7	0	6	0	3	0	0	0
Undetermined	2	1	0	1	0	0	0	0

X-ray technician manpower

Correction of x-ray equipment deficiencies does not provide assurance that radiation exposure to the operator and the general public is at its lowest practical level. As mentioned earlier, the improper use of variable collimators, the improper use of cones when proper cones were available, and the improper palcement of the personnel monitoring film badge, resulting in possible invalid dose equivalent values being recorded, negated their value. These are examples of a poor understanding of radiation protection on the part of the x-ray operator. In order to obtain the overall objective of prevention or reduction of unnecessary radiation exposure from the diagnostic medical uses of x ray, the individuals who operate the x-ray equipment must be well versed in radiation protection as well as in the techniques necessary for a good radiograph.

The North Dakota State Department of Health instituted a survey in 1968 to obtain information on the extent of training and experience of the operators of x-ray equipment in the healing arts. A total of 387 X-ray Technician Manpower Survey forms were mailed. Of these, 248 forms were returned with 218 forms completed for a 63.9 percent return. Two major groups are categorized in this discussion: registered radiological technologists and non-registered x-ray technicians.

To define the term "registered technologist", it was specified that the individual must have attended a planned program of training in a school of radiologic technology and/or be registered with the American Registry of Radiologic Technologists.

From the 218 replies, 84 (38 percent) were registered radiologic technologists and 107 (49 percent) were non-registered technicians. Students enrolled in approved schools of x-ray technology accounted for the remainder of those replying.

The American Registry of Radiologic Technologists indicated that there were 170 certified registered radiologic technologists in the State of North Dakota (7). Therefore, approximately 50 percent of the radiologic technologists are either not practicing for one reason or another or did not return the manpower survey form.

As of July 29, 1968, 65 radiologic technologists were listed as active members of the North Dakota Society of Radiologic Technologists. Since this society has an active education program, there is a need to increase membership in the State society to reach all registered technologists and keep them abreast of recent developments in radiographic techniques and radiation protection.

Personal characteristics

A look at the personal characteristics of the total group (table 9) reveals that 64 percent of the group were female, 59 percent of whom were married. Of the men, 92.5 percent were married.

Table 9. Sex, age, and marital status of radiologic technologists and non-registered technicians by facility where employed

		Registered technologists					Non-registered technicians			
		Hospitals	Clinics	Hospitals and clinics	Private offices	Other	Hospitals	Clinics	Hospitals and clinics	Private offices
Sex:										
Male		24	7	6	0	1	18	8	3	0
Female		19	14	8	5	0	38	32	2	5
Not reported		0	0	0	0	0	1	0	0	0
Total		43	21	14	5	1	57	40	5	5
Age:										
≤24	Male	8	0	1	0	1	7	1	0	0
	Female	4	8	5	3	0	10	5	2	0
25–34	Male	7	4	3	0	0	5	4	0	0
	Female	6	1	3	2	0	12	9	0	1
35–44	Male	6	1	1	0	0	5	2	2	0
	Female	4	2	0	0	0	10	11	0	0
45–54	Male	2	1	0	0	0	1	1	1	0
	Female	2	1	0	0	0	2	7	0	2
≥55	Male	1	1	1	0	0	0	0	0	0
	Female	3	2	0	0	0	3	0	0	1
Not reported		0	0	0	0	0	2	0	0	1
Marital status:										
Single:	Male	2	0	0	0	0	1	0	1	0
	Female	9	7	3	1	0	15	8	0	2
Married:	Male	22	7	6	0	1	16	8	2	0
	Female	8	7	5	4	0	20	24	2	3
Widowed or divorced:	Male	0	0	0	0	0	1	0	0	0
	Female	2	0	0	0	0	3	0	0	0
Not reported		0	0	0	0	0	1	0	0	0

The data indicate that 58 percent of the females and 61 percent of the males were less than 35 years of age. Comparing the registered and non-registered groups 67 percent of the registered group are less than 35 years of age, whereas 45.5 percent of the non-registered group are in that age category.

Type of x-ray training of the non-registered technician

In comparing the training of the registered technologist and non-registered technicians (table 10), the registered technologist either completed a formal training program (minimum of 24 months in a planned program of training in a school of radiologic technology) and/or completed on-the-job training which qualified him for registration with The American Registry of Radiologic Technologists. The type of training received included diagnostic x ray only (23 percent); diagnostic and therapeutic x ray (51 percent); diagnostic, therapeutic and radioisotope training (20 percent), while 6 percent did not indicate the specific type of training. Of the nonregistered technicians, 76 percent had less than one year of x-ray training. In addition to lack of extensive training, 74 percent indicated that radiological health and/or x-ray protection were not included in their training. Although the largest percentage of the nonregistered technicians had no formal training, 51 percent indicated they received their training from a radiologist, a registered technologist, or a combination of both.

Employment distribution of registered and non-registered technicians

Hospitals and multiple specialty clinics employ 93 percent of the registered technologists (table 11) and 95 percent of the non-registered technicians (table 12). Based on data from the x-ray protection and x-ray technician manpower surveys, x-ray technicians were not employed by chiropractors, chiropodists and osteopaths.

Even with the small number of x-ray resurveys conducted throughout the State, a large turnover of x-ray technicians had been observed. In order to gain an idea of the overall rate of turnover, the technicians were questioned on the duration of present employment and the number of years employed as an x-ray technician. As to the length of time employed at their present location, both the registered technologists and non-registered technicians reported approximately 71 percent had been employed for less than 5 years. There is little difference in the reported length of employment

Table 10. Non-registered technicians—type of x-ray training

	Duration of training period					Title of instructor							X-ray protection training received		
	<6 months	6 months to 1 year	>1 year	Degree	N.D.[a]	Rad[b]	RT[c]	Rad & RT	Phy[d]	Phy & RT	Other	N.D.[a]	Yes	No	N.D.[a]
Hospitals	24	18	8	2	5	4	19	9	12	4	4	5	40	9	8
Clinics	13	20	7	0	0	5	7	6	16	5	1	0	32	5	3
Hospitals and clinics	2	2	1	0	0	1	2	1	0	0	0	1	3	2	0
Private offices	0	2	3	0	0	0	0	1	4	0	0	0	3	1	1
Total	39	42	19	2	5	10	28	17	32	9	5	6	70	17	11

[a] No data.
[b] Radiologist.
[c] Radiologic technologist.
[d] Physician.

Table 11. Employment distribution of radiologic technologists

	Employment status		Length of time at present location					Length of time in x-ray field				
	Full-time	Part-time	<1 year	1–5 years	6–10 years	>10 years	N.D.[a]	<1 year	1–5 years	6–10 years	>10 years	N.D.[a]
Hospitals	37	6	13	18	3	9	0	5	14	8	16	0
Clinics	21	0	6	6	2	7	0	1	8	2	10	0
Hospitals and clinics	14	0	4	8	0	2	0	3	7	2	2	0
Private offices	4	1	3	1	1	0	0	2	1	1	0	1
Other	1	0	1	0	0	0	0	0	1	0	0	0
Total	77	7	27	33	6	18	0	11	31	13	28	1

[a] No data.

Table 12. Employment distribution of non-registered technicians

	Employment status			Length of time at present location					Length of time in x-ray field				
	Full-time	Part-time	N.D.[a]	<1	1–5	6–10	>10	N.D.[a]	<1	1–5	6–10	>10	N.D.[a]
Hospitals	38	19	0	20	25	6	6	0	9	19	14	9	6
Clinics	34	5	1	8	20	7	4	1	6	14	8	9	3
Hospitals and clinics	5	0	0	2	0	1	2	0	2	0	1	2	0
Private offices	4	0	1	0	1	0	3	1	0	0	1	3	1
Total	81	24	2	30	46	14	15	2	17	33	24	23	10

[a] No data.

in the field of x ray for the registered technologist and non-registered technician. The registered technologists reported 50 percent had been in x-ray work less than 5 years, whereas the non-registered technicians reported 47 percent had worked less than 5 years. There is a 5 percent difference between the number of registered technologists and the number of non-registered technicians who had worked longer than 5 years. Conversely, 13 percent of the non-registered technicians were working on a part-time basis as compared to 8 percent of the registered technologists.

There is a difference between the workload of the facility which employs a registered technologist as opposed to one which employs a nonregistered technician. Facilities employing the registered technologist averaged 61 radiographic patients and 12 fluoroscopic patients per week with an average of three radiographic exposures per patient. Facilities employing the nonregistered technician averaged 21 radiographic patients and three fluoroscopic patients per week with an average of two radiographic exposures per patient. This difference was expected since the registered technologist is employed in hospitals and multiple-specialty clinics where more sophisticated x-ray procedures are conducted, resulting in more radiographs per patient.

In review, 49 percent of the individuals operating x-ray equipment in North Dakota are not registered with the American Registry of Radiologic Technologists. It appears that the non-registered technician remains in the field of x ray for approximately the same length of time as the registered technologist, although 76 percent of the non-registered technicians have had less than 1 year of x-ray training.

The X-ray Technician Manpower Survey contained a question which asked if the x-ray technicians would be interested in attending a short course or seminar on radiological health and/or x-ray protection. Over 85 percent responded favorably to the proposed course; however, scheduling problems have arisen for the technician in the small facility due to the difficulty of leaving the facility for even 1 day. It is encouraging, however, that the technicians have expressed this interest in increasing their skills and understanding of radiation protection in x-ray facilities.

Summary

Approximately 8,500 patients are radiographed per week in the healing arts specialties, for a total of 443,500 patients per year. Eighty-one percent of the radiographs are performed in hospitals and multiple-specialty clinics. An average of 881 patients receive a fluoroscopic examination each week for a total of 45,812 examinations per year. Of this fluoroscopic workload, 88 percent are conducted in hospitals and multiple-specialty clinics.

Fifty-eight percent of the diagnostic x-ray machines were found to be deficient upon initial evaluation. The majority of the deficiencies were with respect to inadequate collimation and/or inadequate filtration of the useful x-ray beam. Major deficiencies resulting in an unnecessary addition to the genetically significant dose were found to exist in facilities that expose 195,676 persons annually.

Currently, complete resurveys are being conducted to determine the degree of compliance with the recommendations of the initial evaluation and with the Radiological Health Regulations (*8*).

Correction of x-ray equipment deficiencies does not provide assurance that radiation exposure to the operator and the general public is at its lowest practical level. In numerous instances the technicians have not made use of radiation protection devices and equipment available within the facility. As indicated from the X-ray Technician Manpower Survey, 40 percent of the individuals operating x-ray equipment in North Dakota are not registered with The American Registry of Radiologic Technologists. Of the non-registered technicians, 76 percent had less than a year of x-ray training and 74 percent indicated aspects of x-ray protection were not included in their training. It is firmly believed that to obtain the maximum benefit from the use of diagnostic x ray with least human radiation exposure, education must be the key.

REFERENCES

(*1*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, (May 13, 1960).

(*2*) BLATZ, HANSON. Introduction to Radiological Health. McGraw-Hill Book Company (1964).

(*3*) NATIONAL COMMITTEE ON RADIATION PROTECTION AND MEASUREMENTS. Medical X-ray Protection Up to Three Million Volts, National Bureau of Standards Handbook 76. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (February 9, 1961).

(*4*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. Medical X-ray and Gamma-Ray Protection for Energies Up to 10 MeV, Equipment Design and Use, NCRP Report No. 33. NCRP Publications, Washington, D.C. 20008 (February 1968).

(*5*) PUBLIC HEALTH SERVICE. Report of the Medical X-ray Advisory Committee on Public Health Considerations in Medical Diagnostic Radiology (X-Rays), October 1967. Bureau of Disease Prevention and Environmental Control, National Center for Radiological Health, Rockville, Md.

(*6*) FESS, R. and L. C. SEABRON. Preliminary Results of 5263 X-ray Protection Surveys of Facilities with Medical X-ray Equipment, MORP 68–6. PHS, Bureau of Radiological Health, (revised September 1968).

(*7*) AMERICAN SOCIETY OF RADIOLOGIC TECHNOLOGISTS. The American Registry of Radiologic Technologists, Spetember 1967.

(*8*) NORTH DAKOTA STATE DEPARTMENT OF HEALTH. North Dakota State Department of Health, Radiological Health Regulations, Regulation 33, March 1, 1968.

Strontium and Plutonium Isotopes in Ground Level Air October 1963-March 1969

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Data are presented on monthly concentrations of strontium-90, strontium-89, plutonium-239, and plutonium-238 in ground level airborne particulates collected at Winchester, Mass. from October 1963 (for radioisotopes of strontium) and May 1965 (for radioisotopes of plutonium) to March 1969. The ratio of strontium-89 to strontium-90 in these samples indicates an influx of strontium-90 following all but the sixth atmospheric detonation on the Chinese mainland. It is estimated that in 1968 approximately 60 percent of the strontium-90 present in ground level air was of post-1963 origin. The ratio of plutonium-239 to strontium-90 prior to February 1968 was 0.017 ± 0.009. There was a gradual increase in this ratio later in 1968 which is attributed to debris following the sixth, seventh, and eighth tests on the Chinese mainland. Levels of plutonium-238 in SNAP-9A debris in ground level air are somewhat lower than had been predicted.

The radionuclides, strontium-90, strontium-89, plutonium-239[2], and plutonium-238, are present in the atmosphere as the result of nuclear weapons tests. In the case of plutonium-238 (in addition to the above source) an injection of this radioisotopes into the atmosphere took place in April 1964 when 17 kilocuries of plutonium-238, contained in a SNAP-9A power source, burned up south of the equator off the coast of Africa (*1*). Information on airborne strontium and plutonium isotopes is of interest in evaluating the potential health hazards of these materials and in investigating the transport processes involved. Analysis of ground level airborne particulate samples for the radioisotopes of strontium has been performed at the Northeastern Radiological Health Laboratory (NERHL) since October 1963. For the plutonium isotopes, radiochemical and alpha spectroscopic analysis has been done since May 1965. Results of these analyses to April 1966 (for strontium-90) and to February 1967 (for the plutonium isotopes) have been previously reported (*2*, *3*). Extensive measurements of these radionuclides in air particulates and precipitation have been performed by the Health and Safety Laboratory (HASL) of the Atomic Energy Commission (AEC) for several years (*4*, *5*). In addition, the Joint Nuclear Research Center, ISPRA Establishment, Italy, has published data on SNAP-9A plutonium-238 (*6*).

Results on ground level airborne concentrations of the above radionuclides from the inception of the sampling and analysis program at NERHL to March 1969 are presented. A recent assessment of doses from these radionuclides based on their concentrations, indicates that only an infinitesimal portion of the total strontium-90 dose to bone is due to inhalation of airborne material. On the other hand, the dose from plutonium-239 to the tracheobronchial lymph nodes was reported to be 160 millirem in 50 years, second in magnitude only to the dose from strontium-90 to the bone. The dose from plutonium-238 to this lymphatic tissue was about one-quarter of that from plutonium-239 (*7*). Attention will be given to the origin of these radionuclides and to the contribution of various atmospheric nuclear tests and the burnup of the SNAP-9A satellite to the total quantity of the radionuclides present in ground level air. A summary of reported atmospheric detonations or vents which occurred during the period of this study is given in table 1 (*8*).

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[2] The energies of the alpha particles from plutonium-239 and plutonium-240 are not sufficiently different to be separated by alpha-particle spectroscopy. Therefore, when plutonium-239 is referred to in this report, it is meant to represent the sum of the activities of plutonium-239 and plutonium-240.

Table 1. Reported atmospheric detonations (*8*)

Date	Source	Comments
October 16, 1964	Chinese mainland (1st)	Low[a]
May 14, 1965	Chinese mainland (2nd)	Low
May 9, 1966	Chinese mainland (3rd)	Intermediate 200 kilotons (kt)
July 2, 1966	French	25–30 kt
July 19, 1966	French	70–80 kt
September 11, 1966	French	120 kt
September 24, 1966	French	150 kt
October 4, 1966	French	Intermediate 200–300 kt
October 27, 1966	Chinese mainland (4th)	Low-intermediate 20–200 kt
December 28, 1966	Chinese mainland (5th)	Few hundred kt
June 5, 1967	French	Low
June 17, 1967	Chinese mainland (6th)	2 megaton (Mt)
June 27, 1967	French	Low
July 2, 1967	French	Low
December 24, 1967	Chinese mainland (7th)	Megaton range
July 7, 1968	French	Low
July 15, 1968	French	Low
August 3, 1968	French	Low
August 24, 1968	French	2 Mt
September 9, 1968	French	2 Mt
December 28, 1968	Chinese mainland (8th)	2 Mt

[a] Less than 20 kilotons.

Sampling and analysis procedures

Monthly composite particulate samples, representing 12,000 m^3 of air, are collected on 8- by 10-inch membrane filters (pore size 0.8 micron) at a height of 1 meter above the ground. The samples are wet ashed with a mixture of nitric and perchloric acids. The sample is split into two parts for radiochemical analysis.

One-half of the sample is analyzed for strontium–90 and strontium–89. Strontium carrier is added, and the strontium is precipitated from the samples first as the carbonate, then as the nitrate. Further purification is made by barium chromate precipitation and hydroxide scavenging. After an ingrowth period, yttrium carrier is added and the yttrium is extracted into TTA (2-thenolytrifluoroacetate) at pH = 5.0. The yttrium is stripped from the TTA with dilute nitric acid, precipitated as the oxalate and counted for beta particles of yttrium–90. The strontium is precipitated as the carbonate and counted for beta particles of total radiostrontium. The strontium–89 activity is calculated from the total radiostrontium measurement after correction for strontium–90 content.

Analysis of the other half of the sample for the plutonium isotopes is begun by adding plutonium–236 tracer. The plutonium is reduced to the +3 state and coprecipitated with lanthanum fluoride. The lanthanum fluoride is converted to lanthanum hydroxide and dissolved in 7.2 $\underline{M}$ nitric acid. The plutonium is oxidized to the +4 state. The solution is passed over an anion exchange resin in the nitrate form. The resin is washed with additional nitric acid and then with 9 $\underline{M}$ hydrochloric acid. The plutonium is then eluted from the resin with a mixture of 0.36 $\underline{M}$ hydrochloric acid and 0.01 $\underline{M}$ hydrofluoric acid, electroplated onto a stainless-steel planchet from a sulfuric acid-ammonium sulfate electrolyte, and counted with a silicon surface barrier detector linked to a multichannel analyzer. With the sample electroplated onto a 3.1 cm^2 area, the counting efficiency is ~31 percent and resolution 75 keV.

The minimum detectable quantities are 0.10 fCi/m^3, 0.40 fCi/m^3, and 0.003 fCi/m^3 for strontium–90, strontium–89, and the plutonium isotopes, respectively. The maximum 2σ counting error for strontium–90 is approximately 10 percent of the reported value. The corresponding values for strontium–89 are about twice as high. The maximum 2σ counting errors are 50 percent and 67 percent of the reported values for plutonium–239 and plutonium–238, respectively, but are appreciably lower as the values increase above the minimum detectable levels.

Results and discussion

The results of strontium–90 analyses of ground level airborne particulates from monthly composite samples are presented in figure 1. Difficulties in sampling and analysis caused the loss of two samples (October 1963 and August 1967), and during a change over in personnel responsible for collection and analysis of the data, several months of ambiguous data (September, October, November, and December 1967) occurred. Figure 1 illustrates the expected spring maximum which occurs each year and which appears to be extremely reproducible in terms of time of appearance. A line (solid) indicating the expected spring maximum highs, based on the strontium–90 concentrations in the spring of 1964 and a stratospheric residence half-time of 10 months (*9*), is shown. The expected strontium–90 curve (dashed), having the shape of the 1964 curve, because no fresh

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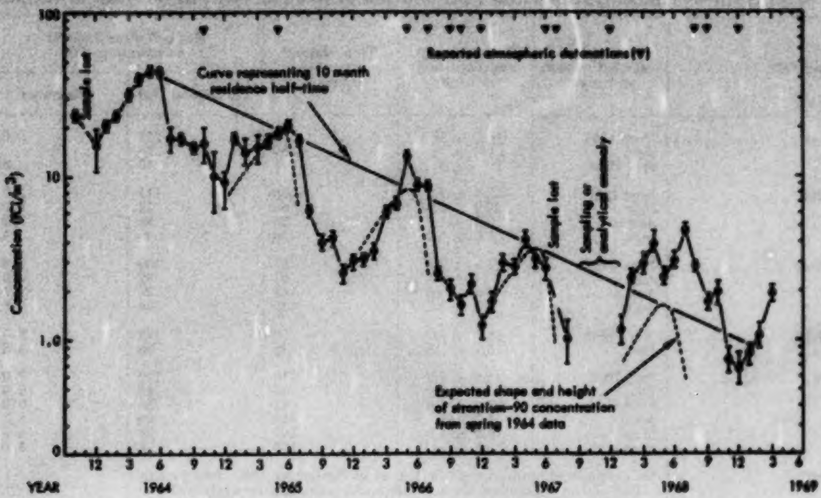

Figure 1. Strontium-90 in ground level air

intrusion of material occurred until the end of that year, is also shown. The difference between the expected and actual curves indicates strontium-90 of post-1963 origin was present.

A double peak in strontium-90 levels appears in 1968. Although not apparent from this study, other investigators have noted the presence of fresh fission products during August 1968 and attribute the rise in radioactivity to the rapid movement of debris from the French tests in July 1968 (*10*). Strontium-90 levels in the latter part of 1968 would be elevated if such an intrusion occurred. Another possibility is an influx of strontium-90 of stratospheric origin, although this is not apparent from the strontium-89 to strontium-90 ratios discussed later.

Strontium-89 concentrations are shown in table 2. Strontium-89 values are indicated only in months where the levels of this radionuclide were above the minimum detectable level. All the appearances of strontium-89 followed atmospheric tests on the Chinese mainland. This fact, together with information that, except in the case noted above, French tests were not measurable above 10°N latitude (*11*) and that the reported yields of releases at the Nevada Test Site (NTS) were low and of a limited nature (*8*), appears to make the detonations on the Chinese mainland the principal source of increases above the expected strontium-90 levels.

The contribution of strontium-90 from a particular test may be estimated from the strontium-89 to strontium-90 ratio. These estimates are also presented in table 2. The theoretical ratios are based on production yields for uranium-235 fission (*12*) and are corrected for decay time between the nuclear test and the time of collection. In most cases, the contribution of strontium-90 in ground level air from a recent nuclear test based on the strontium-89 ratios, appears to be of tropospheric origin. However, the strontium-89 to strontium-90 ratio following the fifth test on the Chinese mainland appears to be influenced by the presence of strontium-89 of stratospheric origin beginning in March of 1967.

Early low yield tests on the Chinese mainland contributed only small amounts to ground level strontium-90 concentrations. The fifth test on the Chinese mainland (December 28, 1966) appears to have contributed a substantial quantity of strontium-90. There was no evidence of a fresh strontium-90 intrusion following the sixth test on the Chinese mainland (June 17, 1967), although complete data are not available. For the 2 months

Table 2. Strontium-89 concentrations and contribution of fresh strontium-90 from atmospheric tests

Test and date	Sample collected (month and year)	Strontium-89 concentration (fCi/m³)	Time elapsed since test (days)	Ratio of strontium-89 to strontium-90		Strontium-90 from test (percent)
				Theoretical (10)	Measured	
Chinese mainland (1st) (Oct. 16, 1964)	Nov. 1964	10 ± 2[a]	30	111	1.6	1.5
	Dec.	[b]	60	74	[b]	—
	Jan. 1965	16 ± 3	91	49	.8	1.6
Chinese mainland (2nd) (May 14, 1965)	June 1965	37.0 ± 2.7	30	111	2.9	2.9
	July	28.2 ± 2.6	60	74	1.7	2.3
	August	2.4 ± 1.1	90	50	.3	.8
	Sept.	1.5 ± 1.2	120	33	.4	1.2
Chinese mainland (3rd) (May 9, 1966)	June 1966	13.1 ± 2.8	37	100	1.8	1.8
	July	10.4 ± 1.7	67	67	2.2	3.3
	August	4.2 ± .8	103	38	1.7	4.4
	Sept.	1.8 ± .7	130	25	.9	3.6
Chinese mainland (4th) (Oct. 27, 1966)	Nov. 1966	18.7 ± 1.7	19	129	8.5	6.6
	Dec.	6.5 ± .8	49	86	5.3	6.2
Chinese mainland (5th) (Dec. 28, 1966)	Jan. 1967	11.9 ± 1.2	19	129	7.0	5.4
	Feb.	15.5 ± 1.1	49	86	5.3	6.2
	March	27.4 ± 1.8	81	55	9.9	18
	April	34.7 ± 1.6	112	38	8.3	22
	May	14.0 ± 1.8	142	24	4.5	19
	June	5.3 ± .9	173	16	2.0	13
Chinese mainland (6th) (June 17, 1967)	No evidence of strontium-89 in August or September 1967. July sample lost and in September through December sampling or analytical ambiguities occurred.					
Chinese mainland (7th) (Dec. 24, 1967)	Jan. 1968	6.5 ± .6	22	124	5.9	4.7
	Feb.	18.3 ± 1.1	53	81	7.2	11
	March	14.8 ± 1.1	81	55	5.1	9.3
	April	13.1 ± 1.1	111	36	3.4	9.5
	May	3.1 ± .7	141	24	1.3	5.5
	June	2.9 ± .3	172	16	.9	5.6
Chinese mainland (8th) (Dec. 28, 1968)	Feb. 1969	2.3 ± .5	48	87	2.2	2.5

[a] 2σ counting error.
[b] Not determined.

following the test for which results were available, there was no indication of elevated strontium-89 levels. Data from the Health and Safety Laboratory (HASL) also indicate the absence of strontium-89 from this test[3] (*11*).

From the differences in projected and actual levels of strontium-90, an estimate of the strontium-90 from atmospheric testing after 1963 can be made. Table 3 presents the mean predicted (based on a 10-month residence half-time and the mean 1964 results) and measured strontium-90 concentrations in ground level air. Because of the magnitude of errors in analyses, it is believed that only the values for 1968 are truly significant, although a gradual increasing trend in newly injected strontium-90 since 1965 is indicated. In 1968, 62 percent of the total ground level strontium-90 was due to post-1963 tests. HASL estimates that 71 percent of the total reservoir of strontium-90 in 1968 could be attributed to post-1963 debris (*14*).

Table 3. Estimated contribution of post-1963 tests to strontium-90

Year	Mean strontium-90 concentration (fCi/m³)		Estimated contribution post-1963 tests (percent)
	Predicted	Measured	
1964	[a]24.1	24.1	—
1965	10.5	11.3	7
1966	4.6	4.6	—
1967	2.0	[b]2.3	15
1968	.9	2.4	62

[a] Predicted value based on measured results for 1964.
[b] No data for July, October, November, and December 1967.

Concentrations of plutonium-239 in ground level air particulates are presented in figure 2. The pattern of minimum and maximum is similar to that for strontium-90. The same limitations (sample loss and ambiguity) hold as for the strontium-90 data. The average ratio of plutonium-239 to strontium-90 for the period, May 1965 through February 1968, was 0.017 with a 2σ range of ±0.009. There is a gradual rise in this ratio fol-

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[3] It has been suggested that this device exploded at a comparatively low altitude (14 km), but that the bulk of the debris was carried to a high altitude by the rising fire-ball (*13*).

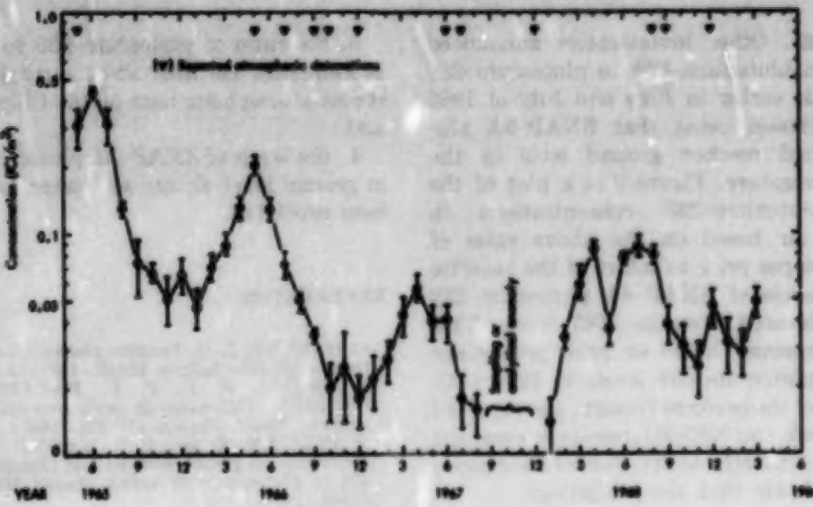

Figure 2. Plutonium-239 in ground level air

lowing this period, the average value being 0.028 from March 1968 to March 1969. This increase in the plutonium-239 to strontium-90 ratio is attributed to debris from the sixth, seventh, and eighth tests on the Chinese mainland, which were reported to be high yield events.

The ratio of plutonium-238 to plutonium-239 remained relatively constant at 0.04 ± 0.02 from May 1965 to July 1966. A change in the ratio was fairly evident at NERHL in mid-1966 (*3*). This change in ratio indicated a new source of plutonium-238 other than that which was pre-

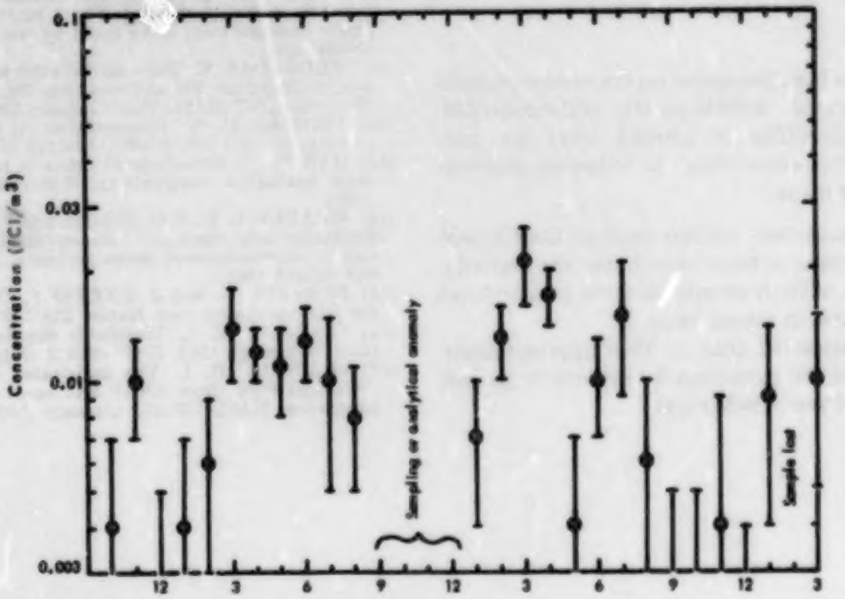

Figure 3. Estimated SNAP-9A plutonium-238 in ground level air

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viously present. Other investigators announced this change in plutonium-238 to plutonium-239 ratio somewhat earlier in June and July of 1968 (*6*), the conclusion being that SNAP-9A plutonium-238 had reached ground level in the Northern Hemisphere. Figure 3 is a plot of the SNAP-9A plutonium-238 concentrations in ground level air based on the above ratio of plutonium isotopes prior to influx of the satellite debris. The levels of SNAP-9A plutonium-238 are slightly elevated over the 1967 levels. This elevation is expected, based on prior predictions of increasing plutonium-238 levels in 1968 (*15*). A comparison of the predicted results, the reported results at ISPRA, and NERHL results is presented in table 4. The NERHL results (3-month averages) are somewhat lower than the predictions.

Table 4. SNAP-9A plutonium in ground level air

Date	Concentration (fCi/m³)		
	Predicted	ISPRA	NERHL
January 1966	0.011	0.001	—
July 1966	.013	.003	—
January 1967	.015	.008	0.004
July 1967	.016	.015	.011
January 1968	.017	.012	.014
July 1968	.018	—	.010

Summary

Data have been presented on the concentrations of strontium-89, strontium-90, plutonium-239, and plutonium-238 in ground level air particulates. From these data, the following observations may be made:

1. the atmospheric nuclear tests on the Chinese mainland appear to have contributed the majority of the influx of fresh strontium-90 in ground level air particulates in recent years,
2. it is estimated that in 1968 approximately 60 percent of the strontium-90 present in ground level air is of post-1963 origin,
3. the ratio of plutonium-239 to strontium-90 is somewhat elevated since early 1968 following recent atmospheric tests on the Chinese mainland, and
4. the levels of SNAP-9A plutonium-238 debris in ground level air are somewhat lower than had been predicted.

REFERENCES

(*1*) HARLEY, J. H. Possible plutonium-238 distribution from a satellite failure. HASL-149:138 (October 1964).

(*2*) MAGNO, P. J., P. E. KAUFFMAN, and B. SHLEIEN. Plutonium in environmental and biological media. Health Physics 13:1325 (1967).

(*3*) SHLEIEN, B. and P. J. MAGNO. Plutonium concentrations in ground level air and changes in plutonium-238 to plutonium-239 ratios. Radiol Health Data Rep 8:561 (1967).

(*4*) VOLCHOK, H. L. and M. T. KLAINMAN. Strontium-90 in surface air, 1963-1967. HASL-204:17 (January 1969).

(*5*) VOLCHOK, H. L. Fallout of plutonium-238 from the SNAP-9A burnup IV. HASL-207:5 (April 1969).

(*6*) DeBORTOLI, M. C. and P. GAGLIONE. SNAP-9A plutonium-238 fallout in Ispra, Italy. Health Physics 16:197 (February 1969).

(*7*) SHLEIEN, B. An evaluation of internal radiation exposure based on dose commitments from radionuclides in milk, food, and air, presented at the 14th annual meeting, Health Physics Society, Pittsburgh, Pa (June 1969).

(*8*) The "Summary of Reported Atmospheric Detonations and Vents" was compiled by the authors from data published in *Radiol Health Data Rep* 1 month following the public announcement of an event by the Atomic Energy Commission.

(*9*) TELEGADAS, K. The seasonal strotospheric distribution of plutonium-238 and strontium-90, March through November 1967. HASL-204:2 (January 1969).

(*10*) THOMAS, C. W. Concentration of airborne radioactivity during 1968. BNWL-1051:85 (June 1969).

(*11*) HARDY, E. Strontium-90 ratios in monthly fallout: some qualitative observations. HASL-200:28 (October 1968).

(*12*) WEAVER, L. E., P. O. STROM, and P. A. KILLEEN. Estimated total chain and independent fission yields for several neutron-induced fission processes. USNRDL-TR-633 (March 1963).

(*13*) PERSSON, G. and J. SISEFSKY. Debris from the 6th Chinese nuclear test. Nature 233:173 (July 1969).

(*14*) VOLCHOK, H. L. Worldwide distribution of strontium-90 through 1968. HASL-210:2 (July 1969).

(*15*) VOLCHOK, H. L. The anticipated distribution of ^{109}Cd and ^{238}Pu (from SNAP-9A) based on ^{102}Rh tracer experience. HASL-165:312 (January 1966).

Technical Notes

Lead Content of Glass Used for Shielding Television Receiver Components and its Relation to Exposure Rate

Harry Levine and *Paul S. Ruggera*[1]

The amount and type of elements of high atomic number in the glass envelopes of certain types of television tubes and x-ray fluoroscopic screens are known to influence the transmission of x rays into the environment. Emissions of x radiation, sometimes exceeding the National Council on Radiation Protection and Measurements (NCRP) recommendations (*1*), have been found to originate from picture tubes, shunt regulator tubes, and high voltage rectifier tubes, particularly under some conditions of operation and construction (*2*).

When conducting inspections of equipment where the transmission of x radiation is in question, it is useful for the inspector to know the lead content of the glass so that its ability to absorb x rays may be estimated. It is desirable, for example, to detect the substitution of nonleaded glass for original or replacement tubes or fluoroscopic screens, and sometimes to check the manufacturer's statement of lead composition.

A rapid, semiquantitative method for the estimation of lead in glass has been developed and has been described in detail elsewhere (*3*). The method is based on the action of a mixture of hydrofluoric acid and sodium iodide and is applicable to glass and ceramics (*4*). An important feature of the test is that the reaction can be performed in a matter of minutes in the field, without causing visible damage to the specimen.

Table 1 presents a comparison of the estimated amount of lead using the "reagent drop method" and the amount determined by conventional methods in various glass specimens.

Table 1. A comparison of lead content in glass specimens determined by conventional methods and by the reagent drop method

Sample identification	Determination by conventional methods (percent PbO)	Approximate estimation by reagent drop method (percent PbO)
Corning glass tube envelope (E-1)	[a] 26.47	25
Corning glass tube envelope (E-2)	[a] Trace	0
#3720 TV picture tube safety panel (SP-1)	[a] 0	0
#3755 or 3770 TV picture tube safety panel (SP-2)	[a] 4.87	5
Corning 9010 TV picture tube face plate	[a] Trace	0
G.E. 6EH4 (GEH-020)	[b] 30.32	30
G.E. 6EL4 (OWE-006)	[b] 30.52	30
Syl. 6BK4C (EMP-008)	[b] 50.06	50
G.E. 6EL4 (OWE-117) new type	[b] 50.25	50

[a] Determined gravimetrically (*5*).
[b] Determined by atomic absorption spectrophotometry (*6*).

Several shunt regulator tubes, both of the earlier and the more recent version, were investigated to evaluate the usefulness of the rapid method in determining a relative correspondence between the amount of lead present in a glass envelope and the resultant x-ray emission from the tube. The tubes were used to expose four 14- by 17-inch film packs made up of a KK type and a commercial type film 22 (Eastman Kodak type S0142, Type S0125, Duo-Ready Pack, Rochester, New York). The film pack was formed into a 17-inch high cylinder, which, when placed around the tube was approximately 5 cm from the tube center line. Exposure was made at 30,000 volts and 0.5 milliamperes for a period of 6 hours. The film was then developed under controlled conditions (new chemicals, constant temperature, gas-burst agitation), so that the exposure rate could be determined using a densitometer and a set of calibration curves which relate density to exposure rate. The calibration of the film pack was performed with a free air ion chamber.

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[1] Messrs. Levine and Ruggera are with the Division of Electronic Products, Bureau of Radiological Health, Environmental Health Service, Rockville, Md. 20852.

Table 2. Relative comparison between lead content of glass envelope and resultant exposure rate

Tube type	Average envelope thickness (in.)	Average lead content		Average net density of film	Average dose rate (mR/h)
		Chemical analysis (percent PbO)	Fast method (percent PbO)		
G.E. 6EH4 GEH-020	0.035	30.32	30	3.78	11.7
G.E. 6EL4 OWE-066	.050	30.52	30	1.10	3.33
Syl. 6BK4C EMP-006	.034	50.06	50	.12	.30
New G.E. 6EL4 OWE-117	.047	50.35	50	.01	*.04

* This value was determined by extrapolation of the calibration curve.

Table 2 presents a comparison between the amount of lead present in the glass envelope and its associated exposure rate. Increasing the lead content between the two, thinner glass envelopes of tubes 6EH4 and 6BK4C reduced the exposure rate by a factor of 40. The other variable, the wall thickness of the envelope, also had some effect. Comparing the 6EH4 with the 6EL4, a reduction factor of 3.5 is observed. Cross comparisons with the new 6EL4 were not made since a density of 0.01 is not a point on the calibration curve. The exposure rate was therefore estimated by extrapolating the curve to that value.

In summary, the field test for lead content of the shunt regulator tube could be a valuable tool in field surveys of sets found to emit excessive radiation. When a field of radiation is detected in the area of the shunt regulator tube, the investigator cannot be sure of the exact source since it could be the shunt, the high-voltage rectifier, or the picture tube. Using the test kit, he can determine, with relative certainty, the lead content of the shunt regulator tube. If the tube contained approximately 50 percent PbO, then it could be eliminated as the defective component. This leaves the high voltage rectifier, which is always in a metal cage for voltage protection, and the picture tube. Since instrumentation is available by which one can determine the beam area, the elimination of the shunt regulator tube from consideration will almost certainly pinpoint the defective component. The picture tube will most probably have a large area beam, whereas the high voltage rectifier would emit a beam only through the air holes in the cage and, therefore, be much smaller in area. A similar set of criteria can be established for components other than the shunt regulator tube to determine the relative comparison of x-ray transmission to lead content.

The use of trade names mentioned in this manuscript does not imply endorsement by the U.S. Public Health Service.

REFERENCES

(*1*) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. National Council on Radiation Protection and Measurements. Radiology 75:122 (1960).

(*2*) STEWART, H. F., N. F. MODINE, E. G. MURPHY, and J. W. ROLOFSON. X-ray patterns and intensities from high voltage shunt regulator tubes for color television receivers. Radiol Health Data Rep 8:675–686 (December 1967).

(*3*) LEVINE, H. and P. S. RUGGERA. A Field Method for the Determination of Lead in Glass Used for Shielding Television Receiver Components. PHS, Bureau of Radiological Health, Division of Electronic Products Report 69-2 (September 1969).

(*4*) KING, J. Museums Journal, Vol. 56 (March 1957).

(*5*) FISHER, G. E. Analysis of Glass. Scott's Standard Methods of Chemical Analysis, Fifth Edition, Vol. 2, pp 2164–2174.

(*6*) JONES, A. H. Analysis of glass and ceramic frit by atomic absorption spectrophotometry. Anal Chem 37: 1761 (1965).

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Tube type	Average envelope thickness (in.)	Average lead content		Average net density of film	Average dose rate (mR/h)
		Chemical analysis (percent PbO)	Fast method (percent PbO)		
G.E. 6EH4 GEH-030	0.035	30.32	30	3.78	11.7
G.E. 6EL4 OWE-008	.050	30.52	30	1.10	3.33
Syl. 6BK4C EMP-006	.034	50.06	50	.12	.30
New G.E. 6EL4 OWE-117	.047	50.35	50	.01	*.04

* This value was determined by extrapolation of the calibration curve.

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REFERENCES

(1) NATIONAL COUNCIL ON RADIATION PROTECTION AND MEASUREMENTS. National Council on Radiation Protection and Measurements. Radiology 75:122 (1960).

(2) STEWART, H. F., N. F. MODINE, E. G. MURPHY, and J. W. ROLOFSON. X-ray patterns and intensities from high voltage shunt regulator tubes for color television receivers. Radiol Health Data Rep 8:675–686 (December 1967).

(3) LEVINE, H. and P. S. RUGGERA. A Field Method for the Determination of Lead in Glass Used for Shielding Television Receiver Components. PHS, Bureau of Radiological Health, Division of Electronic Products Report 69-2 (September 1969).

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(5) FISHER, G. E. Analysis of Glass. Scott's Standard Methods of Chemical Analysis, Fifth Edition, Vol. 2, pp 2164–2174.

(6) JONES, A. H. Analysis of glass and ceramic frit by atomic absorption spectrophotometry. Anal Chem 37: 1761 (1965).

Tritium Concentration in Precipitation, 1967-1968

A. A. Moghissi and *C. R. Porter*[1]

Since the discovery of natural tritium (*1–2*), rain has been extensively monitored to study the production and behavior of this radionuclide in the hydrological cycle (*3*). Although the methodology of early tritium studies (*4*) proved to be somewhat unreliable (*5*), these findings are the basis of our present knowledge regarding the natural concentration and seasonal variation of tritium.

It has been well established that under normal conditions—i.e., in the absence of the introduction of tritium by nuclear bomb testing—tritium concentration in rain will increase during spring and late summer in the Northern Hemisphere (*3*). In the Southern Hemisphere the conditions are similar, although less pronounced (*3*).

Because of the mode of production of natural tritium (*1–3*), it may be expected that the tritium concentration will increase in higher altitudes. Also, numerous studies have shown that tititum concentrations reach a maximum at 45–60° N latitude in the Northern Hemisphere (*3*). There is presently no adequate explanation for this phenomenon.

Rain analysis represents a sensitive technique for monitoring of tritium in the environment. Any significant addition of tritium into the natural cycle can easily and rapidly be detected by rain analysis, primarily due to considerable improvements in the low-level counting techniques for tritium (*6*).

Beginning in 1967, the Bureau of Radiological Health established a tritium in rain network as part of the existing Radiation Alert Network. Ten stations were selected covering the United States, including Alaska and the Hawaiian Islands. The locations of these stations are shown in figure 1.

Procedure

Rain samples from the collection sites are shipped to Rockville, Md., where they are composited on a monthly basis. Part of each monthly composite is transferred to disposable containers and shipped to the Southeastern Radiological Health Laboratory where they are distilled and counted by a liquid scintillation technique. The details of the analytical procedure have been described elsewhere (*7*). It consists of the addition of 20 ml of a scintillation liquid to 5 ml of water in a plastic vial. The scintillation liquid consists of spectrographic grade dioxane containing 7 g diphenyloxazole (PPO), 1.5 g *p*-bis-(o-methylstryl)-benzene(bis-MSB), and 120 g naphthalene per liter. All operations involving the scintillation solution are carried out under red light. Plastic vials, manufactured by Nuclear Chicago Corporation, and a Beckman liquid scintillation counter are used. Under these conditions, a counting efficiency of 22.5 percent was obtained with a background of 8.0 cpm resulting in a sensitivity of 0.40 nCi/liter-cpm.

Duplicate samples were prepared and counted twice for 50 minutes. A background sample was counted before the first sample and a second background after the duplicate sample. If any one of

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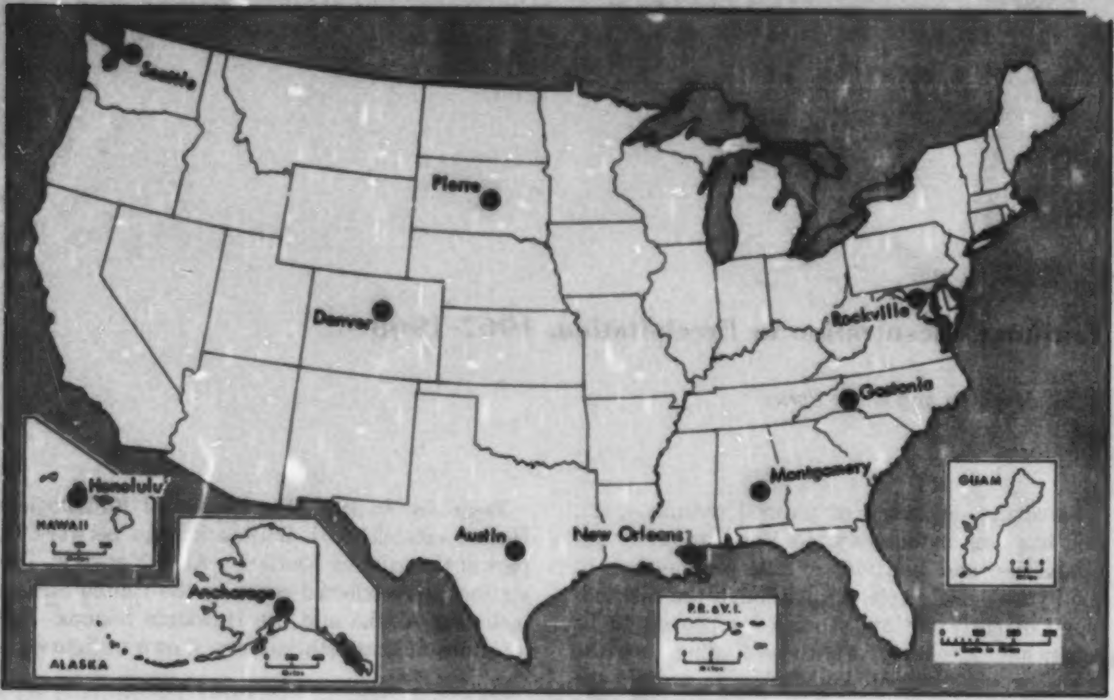

Figure 1. Tritium precipitation stations

the 50-minute sample counts deviated by more than 2-sigma from the average, the duplicates were recounted. This occurred, however, with a frequency comparable to the statistical expectation. The error of the analysis at the 2-sigma confidence level as a function of activity is shown in figure 2. The minimum limit of detection was 0.2 nCi/liter at the 2-sigma confidence level.

The results of this investigation are indicative of radiological health implications of tritium in the atmosphere. It can be clearly seen that tritium in the atmosphere is continuously decreasing as compared to 1965 samples (*3*). Tritium concentrations in rain for previous years are not available from the same geographical locations of this investigation. It is, however, interesting to consider that levels as high as 6 nCi/liter were reported for the continental United States during 1965.

Results

Tables 1 and 2 show the analytical results obtained from the samples collected during 1967 and

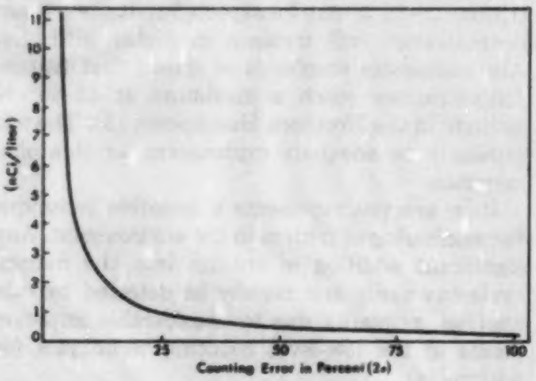

Figure 2. Correlation between tritium concentration of water and counting error in percent at the 2-sigma confidence level

Table 1. Tritium analysis of rain composites from RAN stations, 1967

Location	Concentration (nCi/liter)											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
N.C. Gastonia	0.2	0.5	0.5	0.6	0.3	0.2	0.3	<0.2	0.8	<0.2	<0.2	0.2
Md. Rockville	(a)	.6	.7	1.0	.7	.5	(a)	(a)	(a)	<.2	<.2	<.2
Ala. Montgomery	(a)	.5	<.2	(a)	(a)	<.2	<.2	(a)	.9	1.2	<.2	<.2
S.Dak. Pierre	(a)	(a)	(a)	2.0	2.1	1.3	(a)	(a)	<.2	(a)	(a)	(a)
La. New Orleans	<.2	<.2	.4	<.2	<.2	<.2	.3	<.2	.4	<.2	<.2	<.2
Tex. Austin	<.2	<.2	.5	<.2	<.2	(a)	<.2	<.2	<.2	<.2	<.2	<.2
Colo. Denver	.5	1.0	1.1	2.6	1.7	1.4	1.4	1.1	1.2	.3	.5	.4
Hawaii Honolulu	<.2	.2	.2	.4	<.2	(a)	<.2	<.2	1.4	.3	<.2	<.2
Wash. Seattle	< .2	.4	.7	.6	.7	.5	(a)	(a)	1.6	<.2	<.2	<.2

a Sample not received.

Table 2. Tritium analysis of rain composites from RAN stations, 1968

Location	Concentration (nCi/liter)											
	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
N.C. Gastonia	0.4	<0.2	<0.2	0.5	0.2	0.5	<0.2	(a)	<0.2	<0.2	<0.2	<0.2
Md. Rockville	< .2	(a)	<.2	(a)	(a)	(a)	(a)	<0.2	(a)	<.2	(a)	(a)
Ala. Montgomery	<.2	<.2	.3	.5	.2	.5	<.2	<.2	<.2	<.2	<.2	<.2
Alaska Anchorage	(a)	(a)	(a)	(a)	.5	.5	.7	.7	<.2	<.2	(a)	<.2
La. New Orleans	.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	(a)	(a)	(a)
Tex. Austin	<.2	.9	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	<.2	(a)
Colo. Denver	.4	1.1	.5	1.7	1.2	.6	.5	.4	.6	<.2	.5	(a)
Hawaii Honolulu	<.2	<.2	<.2	<.2	(a)	<.2	(a)	(a)	.5	(a)	<.2	(a)
Wash. Seattle	.2	<.2	<.2	<.2	.3	<.2	<.2	.3	<.2	<.2	<.2	<.2

a Sample not received.

1968. The station at Montgomery, Ala., is not a sample collection site; but due to the availability of this sample, it was run for comparison.

The spring and late summer peaks are clearly detectable in the majority of cases. The station with the highest tritium level is Denver, Colo. Figure 3 shows the tritium concentration of rain samples during the entire sampling period from this station. The reason for the relatively high levels of tritium in rain from Denver is attributed primarily to the high altitude of this location.

The effect of latitude is shown in samples collected from Pierre, S. Dak., from which, unfortunately, only three samples were received. This was the only station within the 45–60° N latitude that

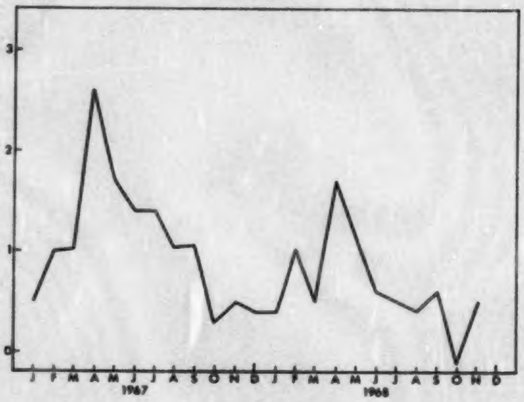

Figure 3. Tritium activity of precipitation in Denver, Colo., during 1967–1968

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would not be affected by dilution from ocean evaporation.

The analysis of samples received during the last 2 months of the sampling period reported was carried out using a suspension technique (*8*) with a minimum limit of detection of 0.1 nCi/liter. As this was in an experimental state and for the sake of uniformity, these values are reported to the same sensitivity as the previously used method.

The analytical technique used, although a sensitive method, is inadequate for any geophysical prediction. An adequate technique for the observation of tritium concentration in rain for this purpose would require a minimum limit of detection of 10–20 pCi/liter of water.

Acknowledgment

The technical assistance of Mae W. Williams and Rachael H. Gorrie in the preparation of this paper is greatly appreciated.

Mention of commercial products used in connection with work reported in this article does not constitute an endorsement by the Public Health Service.

REFERENCES

(*1*) FALTING, V. and P. HARDECK. Tritium content of the atmosphere. Z Naturforsch 5a:438 (1950).

(*2*) GROSSE, A. V., W. H. JOHNSTON, R. L. WOLFGANG, and W. F. LIBBY. Tritium in nature. Science 113:1 (1951).

(*3*) INTERNATIONAL ATOMIC ENERGY AGENCY. Tritium and Other Environmental Isotopes in the Hydrological Cycle, Technical Report No. 73. International Atomic Energy Agency, Vienna (1967).

(*4*) KAUFMAN, S. and W. F. LIBBY. Natural distribution of tritium. Phys Rev 93:1337 (1954).

(*5*) SCHUMACHER, E. Methodology for tritium in natural waters. Helv Chim Acta 43:1019 (1960).

(*6*) MOGHISSI, A. A. Radionuclides in the Environment. Analysis and Public Health Aspects of Environmental Tritium. Advances in Chemistry Series, American Chemical Society, Washington, D.C. (in press).

(7) MOGHISSI, A. A., H. L. Kelley, J. E. REGNIER and M. W. CARTER. Low-level counting by liquid scintillation. 1. Tritium measurement in homogeneous systems. Inter J Appl Rad Isotopes 20:145 (1969).

(*8*) LIEBERMAN, R. and A. A. MOGHISSI. Low-level counting by liquid scintillation. 2. Application of emulsions in tritium measurements. Inter J Appl Rad Isotopes (in press).

Data

SECTION I. MILK AND FOOD

Milk Surveillance, November 1969

Although milk is only one of the sources of dietary intake of environmental radioactivity, it is the food item that is most useful as an indicator of the general population's intake of radionuclide contaminants resulting from environmental releases. Fresh milk is consumed by a large segment of the population and contains several of the biologically important radionuclides that may be released to the environment from nuclear activities. In addition, milk is produced and consumed on a regular basis, is convenient to handle and analyze, and samples representative of general population consumption can be readily obtained. Therefore, milk sampling networks have been found to be an effective mechanism for obtaining information on current radionuclide concentrations and long-term trends. From such information, public health agencies can determine the need for further investigation and/or corrective public health action.

The Pasteurized Milk Network (PMN) sponsored by the Bureau of Radiological Health and the Bureau of Compliance, Food and Drug Administration, U.S. Public Health Service, consists of 63 sampling stations; 61 located in the United States, one in Puerto Rico, and one in the Canal Zone. Many of the State health departments also conduct local milk surveillance programs which provide more comprehensive coverage within the individual State. Data from 15 of these State networks are reported routinely in *Radiological Health Data and Reports*. Additional networks for the routine surveillance of radioactivity in milk in the Western Hemisphere and their sponsoring organizations are:

Pan American Milk Sampling Program (Pan American Health Organization and U.S. Public Health Service)—5 sampling stations

Canadian Milk Network (Radiation Protection Division, Canadian Department of National Health and Welfare)—16 sampling stations

The sampling locations that make up the networks presently reporting in *Radiological Health Data and Reports* are shown in figure 1. Based on the similar purpose for these sampling activities, the present format integrates the complementary data that are routinely obtained by those several milk networks.

Radionuclide and element coverage

Considerable experience has established that relatively few of the many radionuclides that occur in or are formed as a result of nuclear fission become incorporated in milk (*1*). Most of the possible radiocontaminants are eliminated by the selective metabolism of the cow, which restricts gastrointestinal uptake and secretion into the milk.

The five fission-product radionuclides which commonly occur in milk are strontium-89, strontium-90, iodine-131, cesium-137, and barium-140. A sixth radionuclide, potassium-40, occurs naturally in 0.0118 percent (*2*) abundance of the element potassium, resulting in a specific activity for potassium-40 of 830 pCi/g total potassium.

Two stable elements which are found in milk, calcium and potassium, have been used as a means for assessing the biological behavior of metabolically similar radionuclides (radiostrontium and

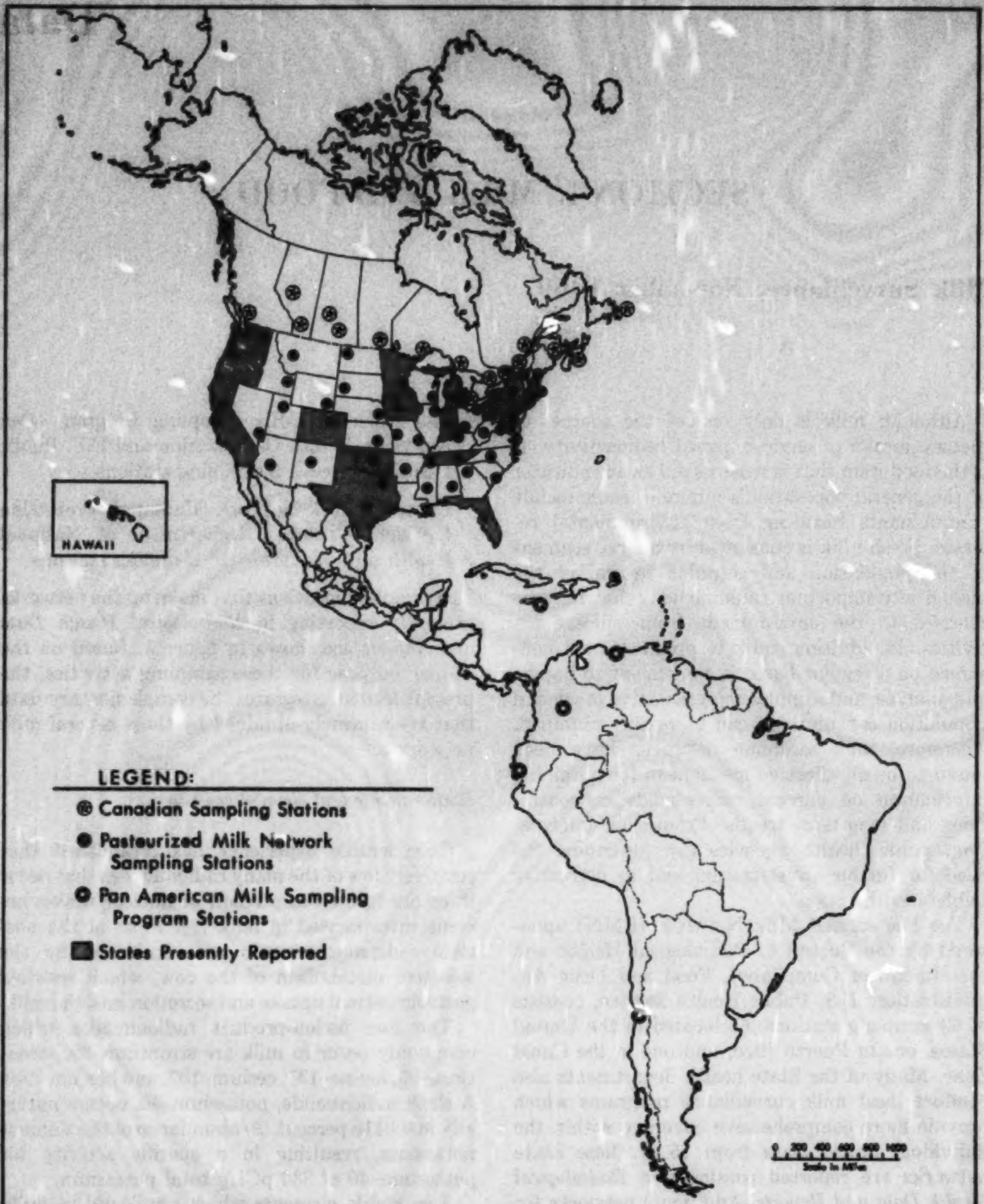
HAWAII
LEGEND:
⊛ Canadian Sampling Stations
● Pasteurized Milk Network Sampling Stations
○ Pan American Milk Sampling Program Stations
▨ States Presently Reported
0 200 400 600 800 1000
Scale in Miles

Figure 1. Milk sampling networks in the Western Hemisphere

radiocesium, respectively). The contents of both calcium and potassium in milk have been measured extensively and are relatively constant. Appropriate values and their variation, expressed in terms of 2-standard deviations, for these concentrations are 1.16 ± 0.08 g/liter for calcium and 1.51 ± 0.21 g/liter for potassium. These figures are averages of data from the PMN for the period, May 1963–March 1966 (*3*) and were determined for use in general radiological health calculations or discussions.

Accuracy of data from various milk networks

In order to combine data from the international, national and State networks considered in this report, it was first necessary to determine the accuracy with which each laboratory is making its determinations and the agreement of the measurements among the laboratories. The Analytical Quality Control Service of the Bureau of Radiological Health conducts periodic studies to assess the accuracy of determinations of radionuclides in milk performed by interested public health radiochemical laboratories. The generalized procedure for making such a study has been outlined previously (*4*).

The most recent study was conducted in the period, July–September 1969, with 31 laboratories participating in an experiment on milk samples containing known concentrations of strontium–89, strontium–90, iodine–131, cesium–137, and barium–140. Of the 19 laboratories producing data for the networks reporting in *Radiological Health Data and Reports*, 15 participated in the experiment.

The iodine–131 and cesium–137 results show much improvement over previous tests. Barium–140 results also look good which is encouraging, since this is the first time barium–140 was analyzed for this type of experiment. However, strontium–89 and strontium–90 analyses still need improvement (*5*). Keeping these possible differences in mind, integration of the data from the various networks can be undertaken without introducing a serious error due to disagreement among the independently obtained data.

Development of a common reporting basis

Since the various networks collect and analyze samples differently, a complete understanding of several parameters is useful for interpreting the data. Therefore, the various milk surveillance networks that report regularly were surveyed for information on analytical methodologies, sampling and analysis frequencies, and estimated analytical errors associated with the data.

In general, radiostrontium is collected by an ion-exchange technique and determined by beta-particle counting in low-background detectors, and the gamma-ray emitters (potassium–40, iodine–131, cesium–137, and barium–140) are determined by gamma-ray spectroscopy of whole milk. Each laboratory has its own modifications and refinements of these basic methodologies. The methods used by each of the networks have been referenced in earlier reports appearing in *Radiological Health Data and Reports*.

A recent article (*6*) summarized the criteria used by the State networks in setting up their milk sampling activities and their sample collection procedures as determined during a 1965 survey. This reference and earlier data articles for the particular network of interest may be consulted should events require a more definitive analysis of milk production and milk consumption coverage afforded by a specific network.

Many networks collected and analyze samples on a monthly basis. Some collect samples more frequently but composite the several samples for one analysis, while others carry out their analyses more often than once a month. The frequency of collection and analysis varies not only among the networks, but also at different stations within some of the networks. In addition, the frequency of collection and analysis is a function of current environmental levels. The number of samples analyzed at a particular sampling station under current conditions is reflected in the data presentation. Current levels for strontium–90 and cesium–137 are relatively stable over short time periods and sampling frequency is not critical. For the short-lived radionuclides, particularly iodine–131, the frequency of analysis is critical, and is generally increased at the first measurement or recognition of a new influx of the radionuclide.

The data presentation also reflects whether raw or pasteurized milk was collected. A recent analysis (*7*) of raw and pasteurized milk samples collected during the period, January 1964 to June 1966, indicated that for relatively similar milkshed or sampling areas, the differences in concentration of radionuclides in raw and pasteurized milk are

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not statistically significant. Particular attention was paid to strontium-90 and cesium-137 in that analysis.

Practical reporting levels were developed by the participating networks, most often based on 2-standard deviation counting errors or 2-standard deviation total analytical errors from replicate analyses experiments (*3*). The practical reporting level reflects additional analytical factors other than statistical radioactivity counting variations and will be used as a practical basis for reporting data.

The following practical reporting levels have been selected for use by all networks whose practical reporting levels were given as equal to or less than the given value.

Radionuclide	Practical reporting level (pCi/liter)
Strontium-89	5
Strontium-90	2
Iodine-131	10
Cesium-137	10
Barium-140	10

Some of the networks gave practical reporting levels greater than those above. In these cases the larger value is used so that only data considered by the network as meaningful will be presented. The practical reporting levels apply to the handling of individual sample determinations. The treatment of measurement equal to or below these practical reporting levels for calculation purposes, particularly in calculating monthly averages, is discussed in the data presentation.

Analytical errors or precision expressed as pCi/liter or percent in a given concentration range have also been reported by the networks (*3*). The precision errors reported for each of the radionuclides fall in the following ranges:

Radionuclide	Analytical errors of precision (2-standard deviations)
Strontium-89	1-5 pCi/liter for levels <50 pCi/liter; 5-10% for levels ≥ 50 pCi/liter
Strontium-90	1-2 pCi/liter for levels <20 pCi/liter; 4-10% for levels ≥ 20 pCi/liter
Iodine-131 Cesium-137 Barium-140	4-10 pCi/liter for levels <100 pCi/liter; 4-10% for levels ≥ 100 pCi/liter

For iodine-131, cesium-137, and barium-140 there is one exception for these precision error ranges: 25 pCi/liter at levels <100 pCi/liter for Colorado. This is reflected in the practical reporting level for the Colorado milk network.

Federal Radiation Council guidance applicable to milk surveillance

In order to place the U.S. data on radioactivity in milk presented in *Radiological Health Data and Reports* in perspective, a summary of the guidance provided by the Federal Radiation Council for specific environmental conditions is presented below. The function of the Council is to provide guidance to Federal agencies in the formulation of radiation standards.

Radiation Protection Guides (*8, 9*)

The Radiation Protection Guide (RPG) has been defined by the Federal Radiation Council (FRC) as the radiation dose which should not be exceeded without careful consideration of the reasons for doing so; every effort should be made to encourage the maintenance of radiation doses as far below this guide as practicable. An RPG provides radiation protection guidance for the control and regulation of normal peacetime uses of nuclear technology in which control is exercised primarily at the source through the design and use of nuclear material. It represents a balance between the possible risk to the general public that might result from exposures from routine uses of ionizing radiation and the benefits from the activities causing the exposure.

Table 1 presents a summary of guidelines and related information on environmental radiation levels as set forth by the FRC for the conditions under which RPG's are applicable. A more detailed discussion of these values was presented earlier (*3*).

In the absence of specific dietary data one can use milk as the indicator food item for routine surveillance. Assuming a 1-liter per day intake of milk, one can utilize the graded approach of daily intake on the basis of radionuclide content in milk samples collected to represent general population consumption. Under these assumptions, the radionuclide concentrations in pCi/liter of milk can replace the daily radionuclide intake in pCi/day in the three graded ranges.

Table 1. Radiation Protection Guides—FRC recommendations and related information pertaining to environmental levels during normal peacetime operation

Radionuclide	Critical organ	RPG for individual in the general population (rad/a)	Guidance for suitable samples of exposed population group[a]				
			RPG (rad/a)	Corresponding continuous daily intake (pCi/day)	Range I (pCi/day)[b]	Range II (pCi/day)[b]	Range III (pCi/day)[b]
Strontium-89	Bone	[c]1.5	0.5	[d]2,000	0-200	200-2,000	2,000-20,000
	Bone marrow	[c].5	.17				
Strontium-90	Bone	[c]1.5	.5	[d]200	0-20	20-200	200-2,000
	Bone marrow	[c].5	.17				
Iodine-131	Thyroid	1.5	.5	100	0-10	10-100	100-1,000
Cesium-137[e]	Whole body	.5	.17	3,000	0-300	300-3,000	3,000-30,000

[a] Suitable samples which represent the limiting conditions for this guidance are: strontium-89, strontium-90—general population; iodine-131—children 1 year of age; cesium-137—infants.

[b] Based on an average intake of 1 liter of milk per day.

[c] A dose of 1.5 rad/a to the bone is estimated to result in a dose of 0.5 rad/a to the bone marrow.

[d] For strontium-89 and strontium-90, the Council's study indicated that there is currently no operational requirement for an intake value as high as one corresponding to the RPG. Therefore, these intake values correspond to doses to the critical organ not greater than one-third the respective RPG.

[e] The guides expressed here were not given in the FRC reports, but were calculated using appropriate FRC recommendations.

Protective Action Guides (*10, 11*)

The Protective Action Guide (PAG) has been defined by the Council as the projected absorbed dose to individuals in the general population that warrants protective action following a contaminating event. A PAG provides general guidance for the protection of the population against exposure by ingestion of contaminated foods resulting from the accidental release or the unforeseen dispersal of radioactive materials in the environment. A PAG is also based on the assumption that such an occurrence is an unlikely event, and circumstances that might involve the probability of repetitive occurrences during a 1 or 2-year period in a particular area would require special consideration. Protective actions are appropriate when the health benefits associated with the reduction in exposure to be achieved are sufficient to offset the undesirable features of the protective actions.

Table 2 presents a summary of guidelines as set forth by the FRC for the conditions under which PAG's are applicable. A more detailed discussion of these values was presented earlier (*3*). Also given in table 2 are milk concentrations for each of the radionuclides considered, in the absence of others, which if attained after an acute incident, would result in doses equivalent to the appropriate PAG. These concentrations are based on a projection of the maximum concentration from an idealized model for any acute deposition and the

Table 2. Protective Action Guides—FRC recommendations and related information pertaining to environmental levels during an acute contaminating event

Radionuclide	Critical organ	PAG for individuals in general population (rads)	Category (pasture-cow-milk)	
			Guidance for suitable sample, children 1 year of age	
			PAG (rads)	Maximum concentration in milk for single nuclide that would result in PAG (pCi/liter)
Strontium-89	Bone marrow	10 in first yr; total dose not to exceed 15[a,b]	3 in first yr; total dose not to exceed 5[a,b]	[c]1,110,000
Strontium-90	Bone marrow			[c]51,000
Cesium-137	Whole body			[c]730,000
Iodine-131	Thyroid	30	10	[d]70,000

[a] The sum of the projected doses of these three radionuclides to the bone marrow should be compared to the numerical value of the respective guide.

[b] Total dose from strontium-89 and cesium-137 is the same as dose in first year; total dose from strontium-90 is 5 times strontium-90 dose in first year for children approximately 1 year of age.

[c] These values represent concentrations that would result in doses to the bone marrow or whole body equal to the PAG, if only the single radionuclide were present.

[d] This concentration would result in the PAG dose based on intake before and after the date of maximum concentration observed in milk from an acute contaminating event. A maximum of 84,000 pCi/liter would result in a PAG dose if that portion of intake prior to the maximum concentration in milk is not considered. Children, 1 year of age, are assumed to be the critical segment of the population.

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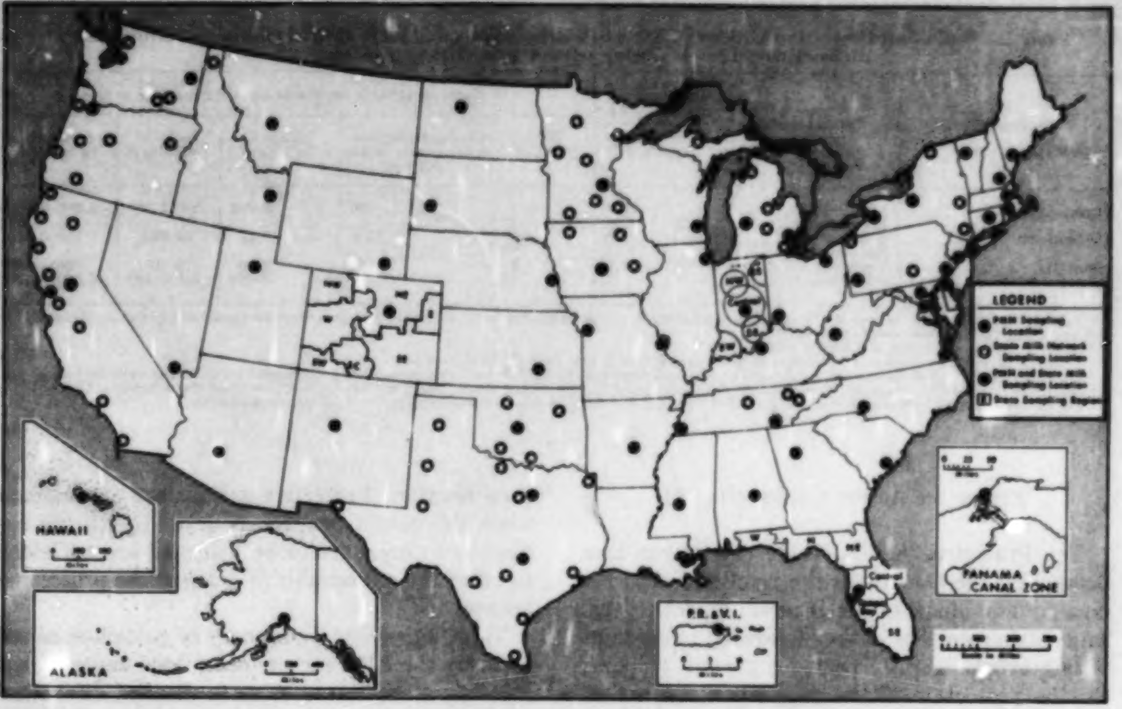

Figure 2. State and PMN milk sampling locations in the United States

pasture-cow-milk-man pathway, as well as an estimate of the intake prior to reaching the maximum concentration. Therefore, these maximum concentrations are intended for use in estimating future intake on the basis of a few early samples rather than in retrospective manner.

Data reporting format

Table 3 presents the integrated results of the international, national, and State networks discussed earlier. Column 1 lists all the stations which are routinely reported to *Radiological Health Data and Reports*. (The relationship between the PMN stations and State stations is shown in figure 2). The first column under each of the radionuclides reported gives the monthly average for the station and the number of samples analyzed in that month in parentheses. When an individual sampling result is equal to or below the practical reporting level for the radionuclide, a value of zero is used for averaging. Monthly averages are calculated using the above convention. Averages which are equal to or less than the practical reporting levels reflect the presence of radioactivity in some of the individual samples greater than the practical reporting level.

The second column under each of the radionuclides reported gives the 12-month average for the station as calculated from the preceding 12-monthly averages, giving each monthly average equal weight. Since the daily intake of radioactivity by exposed population groups, averaged over a year, constitutes an appropriate criterion for the case where the FRC radiation protection guides apply, the 12-month average serves as a basis for comparison.

Discussion of current data

In table 3, surveillance results are given for strontium–90, iodine–131, and cesium–137, for November 1969 and the 12-month period, December 1968 to November 1969. Except where noted, the monthly average represents a single sample for the sampling station. Strontium–89 and barium–140 data have been omitted from table 3 since levels at the great majority of the stations for November 1969 were below the respective practical reporting levels, with the exception of the stations given in table 4.

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Table 3. Concentrations of radionuclides in milk for November 1969 and 12-month period, December 1968 through November 1969

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES:								
Ala:	Montgomery[c]	P	9	7	0 (4)	0	12 (4)	10
Alaska:	Palmer[c]	P	6	6	0 (4)	0	6 (4)	6
Ariz:	Phoenix[c]	P	0	1	0 (4)	0	0 (4)	0
Ark:	Little Rock[c]	P	14	17	0 (4)	0	18 (4)	18
Calif:	Sacramento[c]	P	0	1	0 (4)	0	0 (4)	0
	San Francisco[c]	P	0	2	0 (4)	0	0 (4)	0
	Del Norte	P	20	19	0	0	3	1
	Fresno	P	11	0	0	0	6	0
	Humboldt	P	4	5	0	0	4	8
	Los Angeles	P	2	2	0	0	5	3
	Mendocino	P	3	4	0	0	4	5
	Sacramento	P	2	3	0	0	5	6
	San Diego	P	2	2	0	0	4	4
	Santa Clara	P	1	2	0	0	0	6
	Shasta	P	3	3	0	0	4	7
	Sonoma	P	2	3	0	0	6	6
Colo:	Denver[c]	P	5	5	0 (4)	0	0 (4)	1
	West	R	(f)		NS	(e)	NS	(e)
	Northeast	R	(f)		(e)	(e)	(e)	(e)
	East	R	(f)		(e) (2)	(e)	(e)	(e)
	Southeast	R	(f)		NS	(e)	NS	(e)
	South central	R	(f)		NS	(e)	NS	(e)
	Southwest	R	(f)		(e)	(e)	(e)	(e)
	Northwest	R	(f)		NS	(e)	NS	(e)
Conn:	Hartford[c]	P	6	8	0 (4)	0	10 (4)	12
	Central	P	5	7	0 (4)	0	7 (4)	10
Del:	Wilmington[c]	P	7 (4)	9	0 (4)	0	0 (4)	6
D.C:	Washington[c]	P	7	7	0 (4)	0	9 (4)	5
Fla:	Tampa[c]	P	7	7	0 (2)	0	51 (2)	56
	West	R	12	11	0	0	22	27
	North	R	9	14	0	0	31	29
	Northeast	R	8	6	0	0	44	50
	Central	R	8	7	0	0	27	58
	Tampa Bay area	R	8	8	0	0	45	50
	Southeast	R	12	8	0	0	110	93
Ga:	Atlanta[c]	P	7	10	0 (4)	0	19 (4)	19
Hawaii:	Honolulu[c]	P	3 (4)	3	0 (4)	0	0 (4)	0
Idaho:	Idaho Falls[c]	P	5	5	0 (4)	0	6 (4)	6
Ill:	Chicago[c]	P	7	8	0 (4)	0	6 (4)	10
Ind:	Indianapolis[c]	P	10	8	0 (4)	0	5 (4)	6
	Northeast	P	9	12	0	0	15	10
	Southeast	P	10	8	0	0	10	12
	Central	P	9	9	0	0	10	10
	Southwest	P	11	10	0	0	10	12
	Northwest	P	11	10	0	0	20	16
Iowa:	Des Moines[c]	P	6	5	0 (4)	0	7 (4)	2
	Iowa City	P	NS		NS		NS	
	Des Moines	P	NS		NS		NS	
	Spencer	P	NS		NS		NS	
	Fredericksburg	P	NS		NS		NS	
Kans:	Wichita[c]	P	9	7	0 (4)	0	0 (4)	2
Ky:	Louisville[c]	P	6	9	0 (4)	0	6 (4)	5
La:	New Orleans[c]	P	11	16	0 (2)	0	19 (2)	19
Maine:	Portland[c]	P	11	12	0 (4)	0	20 (4)	23
Md:	Baltimore[c]	P	8	8	0 (4)	0	2 (4)	6
Mass:	Boston[c]	P	9	11	0 (4)	0	20 (4)	21
Mich:	Detroit[c]	P	8	8	0 (4)	0	7 (4)	9
	Grand Rapids[c]	P	9	10	0 (4)	0	8 (4)	14
	Bay City	P	NA	7	0	0	0	8
	Charlevoix	P	NA	9	0 (4)	0	16 (4)	16
	Detroit	P	NA	6	0 (4)	0	9 (4)	8
	Grand Rapids	P	NA	8	0 (4)	0	12 (4)	12
	Lansing	P	NA	6	0 (2)	0	16 (2)	11
	Marquette	P	NA	10	0 (2)	1	21 (2)	28
	Monroe	P	NA	5	0 (2)	1	6 (2)	2
	South Haven	P	NA	7	0	0	NS	8
Minn:	Minneapolis[c]	P	12	10	0 (4)	0	4 (4)	10
	Bemidji	P	16	17	0	0	20	24
	Mankato	P	7	9	0	0	16	0
	Rochester	P	8	8	0	0	0	0
	Duluth	P	17	19	0	0	16	23
	Worthington	P	7	8	0	0	0	0
	Minneapolis	P	9	12	0	0	0	0
	Fergus Falls	P	11	10	0	0	0	0
	Little Falls	P	9	10	0	0	11	11
Miss:	Jackson[c]	P	9	12	0 (4)	0	10 (4)	14
Mo:	Kansas City[c]	P	5	7	0 (3)	0	0 (3)	1
	St. Louis[c]	P	11	8	0 (4)	0	3 (4)	2
Mont:	Helena[c]	P	4	5	0 (4)	0	2 (4)	6
Nebr:	Omaha[c]	P	6	6	0 (4)	0	0 (4)	2
Nev:	Las Vegas[c]	P	0	1	0 (4)	0	0 (4)	0
N.H:	Manchester[c]	P	6	8	0 (4)	0	10 (4)	20
N.J:	Trenton[c]	P	8	9	0 (4)	0	4 (4)	8

See footnotes at end of table.

Table 3. Concentrations of radionuclides in milk for November 1969 and 12-month period, December 1968 through November 1969—Continued

Sampling location	Type of sample[a]	Radionuclide concentration (pCi/liter)					
		Strontium-90		Iodine-131		Cesium-137	
		Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
UNITED STATES—Continued							
N.Mex: Albuquerque[c]	P	2	2	0 (4)	0	0 (4)	-1
N.Y: Buffalo[c]	P	6	7	0 (4)	0	12 (4)	10
New York City[c]	P	9	10	0 (4)	0	14 (4)	13
Syracuse[c]	P	5	8	0 (4)	0	13 (4)	9
Albany	P	5	6	0 (3)	0	(e) (2)	(e)
Buffalo	P	(e)	(e)	0	0	(e)	(e)
Massena	P	5	9	0	0	(e)	(e)
Newburgh	P	11	10	0	0	(e)	(e)
New York City	P	(e)	9	0 (4)	0	(e) (4)	(e)
Syracuse	P	(e)	7	0 (2)	0	(e) (2)	(e)
N.C: Charlotte[c]	P	9	13	0 (4)	0	14 (4)	12
N.Dak: Minot[c]	P	9	10	0 (4)	0	11 (4)	13
Ohio: Cincinnati[c]	P	7	8	0 (4)	0	7 (4)	3
Cleveland[c]	P	8	9	0 (4)	0	3 (4)	7
Okla: Oklahoma City[c]	P	3	8	0 (2)	0	0 (2)	9
Oklahoma City	P	NS		NS		NS	
Enid	P	NS		NS		NS	
Tulsa	P	NS		NS		NS	
Lawton	P	NS		NS		NS	
Ardmore	P	NS		NS		NS	
Ore: Portland[c]	P	7	7	0 (4)	0	6 (4)	6
Baker	P	NA	2	(e)	(e)	NA	9
Coos Bay	P	5	5	(e)	(e)	18	12
Eugene	P	2	4	(e)	(e)	(e)	8
Medford	P	NA	2	(e)	(e)	(e)	17
Portland composite	P	4	3	(e)	(e)	13 (4)	6
Portland local	P	5	5	(e)	(e)	(e) (4)	9
Redmond	P	0	1	(e)	(e)	(e)	4
Tillamook	R	3	6	(e)	(e)	(e)	19
Pa: Philadelphia[c]	P	9	9	0 (4)	0	4 (4)	5
Pittsburgh[c]	P	9	12	0 (4)	0	9 (4)	3
Dauphin	P	5	6	0	1	20	14
Erie	P	8	10	0	6	27	20
Philadelphia	P	6	8	18	3	15	10
Pittsburgh	P	6	10	0	2	16	17
R.I: Providence[c]	P	8	9	0 (4)	0	14 (4)	16
S.C: Charleston[c]	P	11	11	0 (3)	0	22 (3)	23
S.Dak: Rapid City[c]	P	7	8	0 (2)	0	7 (2)	6
Tenn: Chattanooga[c]	P	7	10	0 (4)	0	15 (4)	13
Memphis[c]	P	6	8	0 (4)	0	7 (4)	5
Chattanooga	P	11	13	0 (4)	0	5 (4)	15
Clinton	P	12	15	0 (2)	0	12 (2)	14
Knoxville	P	10	10	0 (2)	0	6 (2)	7
Nashville	P	7	9	0 (2)	0	5 (2)	5
Tex: Austin[c]	P	0	2	0 (4)	0	4 (4)	4
Dallas[c]	P	4	6	0 (4)	0	6 (4)	6
Amarillo	R	NS	4	NS	0	NS	0
Corpus Christi	R	4	4	0	0	0	0
El Paso	R	7	2	0	0	0	0
Fort Worth	R	NS	3	NS	0	NS	2
Harlingen	R	NS	2	NS	0	NS	0
Houston	R	NS	6	NS	0	NS	11
Lubbock	R	5	4	0	0	0	0
Midland	R	NS	3	NS	0	NS	0
San Antonio	R	NS	3	NS	0	NS	0
Texarkana	R	NS	11	NS	0	NS	15
Uvalde	R	3	2	0	0	0	0
Wichita Falls	R	6	6	0	0	10	8
Utah: Salt Lake City[c]	P	4	4	0 (4)	0	0 (4)	5
Vt: Burlington[c]	P	7	8	0 (4)	0	12 (4)	14
Va: Norfolk[c]	P	9	10	0 (4)	0	12 (4)	8
Wash: Seattle[c]	P	7	7	0 (4)	0	6 (4)	12
Spokane[c]	P	7	7	0 (4)	0	4 (4)	5
Benton County	R	0	1	(d)		13	4
Franklin County	R	NS	2	(d)		NS	0
Sandpoint, Idaho	R	11	11	(d)		33	28
Skagit County	R	5	7	(d)		0	14
W.Va: Charleston[c]	P	7	9	0 (4)	0	9 (4)	7
Wis: Milwaukee[c]	P	7	7	0 (4)	0	8 (4)	11
Wyo: Laramie[c]	P	6	5	0 (4)	0	0 (4)	7
CANADA:							
Alberta: Calgary	P	10	8	(d)		16	15
Edmonton	P	6	7	1		14	14
British Columbia: Vancouver	P	10	11	(d)		22	33
Manitoba: Winnipeg	P	8	8	(d)		24	25
New Brunswick: Fredrickton	P	12	13	(d)		12	18
Newfoundland: St. Johns	P	16	17	(d)		22	35

See footnotes at end of table.

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Table 3. Concentrations of radionuclides in milk for November 1969 and 12-month period, December 1968 through November 1969—Continued

Sampling location		Type of sample[a]	Radionuclide concentration (pCi/liter)					
			Strontium-90		Iodine-131		Cesium-137	
			Monthly average[b]	12-month average	Monthly average[b]	12-month average	Monthly average[b]	12-month average
CANADA—Continued								
Nova Scotia:	Halifax	P	12	10	([d])		15	20
Ontario:	Ft. William	P	15	16	([d])		34	31
	Ottawa	P	7	9	([d])		9	15
	Sault Ste. Marie	P	14	15	([d])		28	30
	Toronto	P	4	5	([d])		10	11
	Windsor	P	4	5	([d])		10	12
Quebec:	Montreal	P	8	9	([d])		17	18
	Quebec	P	10	11	([d])		22	28
Saskatchewan:	Regina	P	8	7	([d])		17	12
	Saskatoon	P	7	8	([d])		10	13
CENTRAL AND SOUTH AMERICA:								
Columbia:	Bogota	P	0	1	0	0	0	1
Chile:	Santiago	P	0	0	0	0	0	1
Ecuador:	Guayaquil	P	0	0	0	0	0	0
Jamaica:	Mandeville	P	4	5	0	0	95	95
Venezuela:	Caracas	P	0	1	0	0	0	0
Canal Zone:	Cristobal[c]	P	0	1	0 (4)	0	12 (4)	11
Puerto Rico:	San Juan[c]	P	0	3	0 (4)	0	8 (4)	7
PMN Network average[f]			7	8	0	0	8	9

[a] P, pasteurized milk.
R, raw milk.

[b] When an individual sampling result was equal to or less than the practical reporting level, a value of "0" was used for averaging. Monthly averages less than the practical reporting level reflect the fact that some but not all of the individual samples making up the average contained levels greater than the practical reporting level. When more than one analysis was made in a monthly period, the number of samples in the monthly average is given in parentheses.

[c] PHS Pasteurized Milk Network station. All other sampling locations are part of the State or national network.

[d] Radionuclide analysis not routinely performed.

[e] The practical reporting levels for these networks differ from the general ones given in the text. Sampling results for the networks were equal to or less than the following practical reporting levels:

Iodine-131: Colorado—25 pCi/liter
Michigan—14 pCi/liter
Oregon—15 pCi/liter

Cesium-137: Colorado—25 pCi/liter
New York—20 pCi/liter
Oregon—15 pCi/liter

[f] This entry gives the average radionuclide concentrations for the PHS Pasteurized Milk Network stations denoted by footnote [c].
NA, no analysis.
NS, no sample.

Iodine-131 results are included in the table, even though they were generally below practical reporting levels. Because of the lower values reflected by the radiation protection guidance provided by the Federal Radiation Council (table 1), levels in milk for this radionuclide are of particular public health interest. In general, the practical reporting level for iodine-131 is numerically equal to the upper value of Range I (10 pCi/liter) of the FRC radiation protection guide.

Strontium-90 monthly averages ranged from 0 to 20 pCi/liter in the United States for November 1969, and the highest 12-month average was 19 pCi/liter (Del Norte, Calif., Duluth, Minn.) representing 9.5 percent of the Federal Radiation Council radiation protection guide (table 1). Cesium-137 monthly averages ranged from 0 to 110 pCi/liter in the United States for November 1969 and the highest 12-month average was 93 pCi/liter (southeast Fla.), representing 2.6 percent of the value presented in this report using the recommendations given in the Federal Radiation Council reports. Of particular interest are the consistently higher cesium-137 levels that have been observed in Florida (*12*) and Jamaica. Iodine-131 monthly averages were generally below the practical reporting level, with the following exception: Philadelphia, Pa. (State) 18 pCi/liter.

Table 4. Strontium-89 in milk, November 1969

Sampling location		Radionuclide concentration (pCi/liter)
		Strontium-89
Calif:	Del Norte (State)	10
Mo:	Kansas City (PMN)	7
N.Dak:	Minot (PMN)	11
Okla:	Oklahoma City (PMN)	8

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Colorado State Department of Health

Radiological Health Services
Division of Medical Services
Connecticut State Department of Health

Division of Radiological Health
Bureau of Preventable Diseases
Florida State Board of Health

Bureau of Environmental Sanitation
Division of Sanitary Engineering
Indiana State Board of Health

Division of Radiological Health
Environmental Engineering Services
Iowa State Department of Health

Radiological Health Service
Division of Occupational Health
Michigan Department of Health

Radiation Protection Division
Canadian Department of National Health and Welfare

Radiation Control Section
Division of Environmental Health
State of Minnesota Department of Health

Bureau of Radiological Health
Division of Environmental Health Services
New York State Department of Health

Division of Occupational and Radiological Health
Environmental Health Services
Oklahoma State Department of Health

Environmental Radiation Surveillance Program
Division of Sanitation and Engineering
Oregon State Board of Health

Radiological Health Section
Bureau of Environmental Health
Pennsylvania Department of Public Health

Radiological Health Services
Division of Preventable Diseases
Tennessee Department of Public Health

Division of Occupational Health
Environmental Health Services
Texas State Department of Health

Office of Air Quality Control
Division of Technical Services
Washington State Department of Health

REFERENCES

(1) CAMPBELL, J. E., G. K. MURTHY, A. S. GOLDIN, H. B. ROBINSON, C. P. STRAUB, F. J. WEBER, and K. H. LEWIS. The occurrence of strontium-90, iodine-131, and other radionuclides in milk, May 1967 through April 1968. Amer J Public Health 59:225 (February 1969).

(2) Chart of the Nuclides, Ninth Edition revised to July 1966. Knolls Atomic Power Laboratory (November 1966).

(3) NATIONAL CENTER FOR RADIOLOGICAL HEALTH. Section I. Milk Surveillance. Radiol Health Data Rep 9:730–746 (December 1968).

(4) ROSENSTEIN, M. and A. S. GOLDIN. Statistical technics for quality control of environmental radioassay. Health Lab Sci 2:93 (April 1965).

(5) KNOWLES, F. Interlaboratory study of iodine-131, cesium-137, barium 140, strontium-89, and strontium-90 measurements in milk, July–September 1969, Technical experiment 69, MKAQ-2. Analytical Quality Control Service, Bureau of Radiological Health (October 1969).

(6) NEILL, R. H. and D. R. SNAVELY. State Health Department sampling criteria for surveillance of radioactivity in milk. Radiol Health Data Rep 8:621–627 (November 1967).

(7) ROBINSON, P. B. A comparison of results between the Public Health Service Raw Milk and Pasteurized Milk Networks for January 1964 through June 1966. Radiol Health Data Rep 9:475–488 (September 1968).

(8) FEDERAL RADIATION COUNCIL. Background materials for the development of radiation protection standards, Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 13, 1960).

(9) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

(10) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, Report No. 5. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (July 1964).

(11) FEDERAL RADIATION COUNCIL. Background material for the development of radiation protection standards, protective action guides for strontium-89, strontium-90, and cesium-137, Report No. 7. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1965).

(12) PORTER, C. R., C. R. PHILLIPS, M. W. CARTER, and B. KAHN. The Cause of Relatively High Cesium-137 Concentrations in Tampa, Florida Milk. Radioecological Concentration Processes, Proceedings of an International Symposium held in Stockholm, April 25–29, 1966. Pergamon Press, New York, N.Y. (1966) pp. 95–101.

Food and Diet Surveillance

Efforts are being made by various Federal and State agencies to estimate the dietary intake of selected radionuclides on a continuing basis. These estimates, along with the guidance developed by the Federal Radiation Council, provide a basis for evaluating the significance of radioactivity in foods and diet.

Networks presently in operation and reported routinely include those of nationwide dietary intakes of radionuclides. Programs most recently reported in *Radiological Health Data and Reports* and not covered in this issue are as follows:

Program	Period reported	Issue
California Diet Study	November 1967–September 1968	May 1969
Connecticut Diet Study	July–December 1968 and January–June 1969	February 1970
Radionuclides in Institutional Diet Samples, *PHS*	April–June 1969	January 1970
Strontium-90 in Tri-City Diets, *HASL*	August–December 1968	December 1969

SECTION II. WATER

The Public Health Service, the Federal Water Pollution Control Administration and other Federal, State, and local agencies operate extensive water quality sampling and analysis programs for surface, ground, and treated water. Most of these programs include determinations of gross beta and gross alpha radioactivity and specific radionuclides.

Although the determination of the total radionuclide intake from all sources is of primary importance, a measure of the public health importance of radioactivity levels in water can be obtained by comparison of the observed values with the Public Health Service Drinking Water Standards (*1*). These standards, based on consideration of Federal Radiation Council (FRC) recommendations (*2-4*), set the limits for approval of a drinking water supply containing radium-226 and strontium-90 as 3 pCi/liter and 10 pCi/liter, respectively. Limits may be set higher if the total intake of radioactivity from all sources remains within the guides recommended by FRC for control action. In the known absence[1] of strontium-90 and alpha-particle emitters, the limit is 1,000 pCi/liter gross beta radioactivity, except when additional analysis indicates that concentrations of radionuclides are not likely to cause exposure greater than the limits indicated by the Radiation Protection Guides. Surveillance data from a number of Federal and State programs are published periodically to show current and long-range trends. Water sampling activities recently reported in *Radiological Health Data and Reports* are listed below:

Water sampling program	Period reported	Issue
California	January–June 1968	December 1969
Coast Guard Water Supplies	January 1968–July 1969	February 1970
Colorado River Basin	1967	December 1968
Minnesota	January–June 1969	January 1970
New York	July–December 1968	September 1969
North Carolina	January–December 1967	May 1969
Radiostrontium in Tap Water, *HASL*	July–December 1968	November 1969
Washington	July 1967–June 1968	June 1969

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[1] Absence is taken to mean a negligibly small fraction of the specific limits of 3 pCi/liter and 10 pCi/liter for unidentified alpha-particle emitters and strontium-90, respectively.

REFERENCES

(*1*) U.S. PUBLIC HEALTH SERVICE. Drinking water standards, revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office Washington, D.C. 20402 (March 1963).

(*2*) FEDERAL RADIATION COUNCIL. Radiation Protection Guidance for Federal Agencies. Memorandum for the President, September 1961. Reprint from the Federal Register of September 26, 1961.

(*3*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards Report No. 1. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (May 1960).

(*4*) FEDERAL RADIATION COUNCIL. Background material for the development of Radiation Protection Standards, Report No. 2. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (September 1961).

Radioactivity in Florida Waters, 1968

Division of Radiological Health
Florida State Board of Health

The Florida State Board of Health samples raw surface, ground, and treated water in 13 hydrological subbasins as shown in figure 1. Samples collected on a variable frequency and analyzed for gross alpha and beta radioactivity during 1968 are presented in table 1. Gross alpha and gross beta radioactivity concentrations of less than 7 pCi/liter and less than 10 pCi/liter, respectively, are not reported.

In addition to sampling being done by the Florida State Board of Health, the Bioenvironmental Engineering Research Laboratory, University of Florida, samples surface, ground and municipal water in Alachua County for gross beta radioactivity. Samples are taken monthly from each sampling point with the exception of the City of Gainesville where raw water is sampled daily. These data for 1968 are summarized in table 2. Gross beta radioactivity above the minimum reported concentration was detected in 35 water samples taken in Alachua County. The 35 samples averaged 13 pCi/liter of gross beta radioactivity.

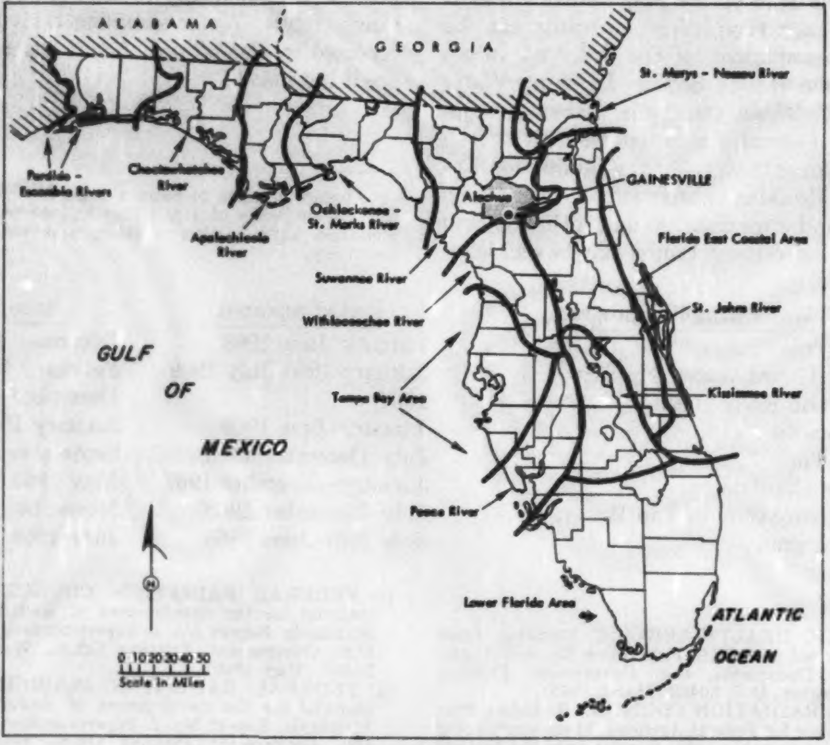
ALABAMA
GEORGIA
St. Marys – Nassau River
Perdido – Escambia Rivers
Choctawhatchee River
GAINESVILLE
Alachua
Ochlockonee – St. Marks River
Apalachicola River
Florida East Coastal Area
Suwannee River
St. Johns River
Withlacoochee River
GULF
OF
MEXICO
Tampa Bay Area
Kissimmee River
Peace River
N
0 10 20 30 40 50
Scale in Miles
Lower Florida Area
ATLANTIC
OCEAN

Figure 1. Hydrological surface subbasins in Florida

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[1] Data taken from "Report of Florida Radiological Surveillance Programs, 1968" Bureau of Preventable Diseases, Division of Radiological Health, Jacksonville, Fla.

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During 1968, only eight samples out of a total of 227 collected from 120 sampling sites indicated gross beta radioactivity greater than the minimum reported concentration. The eight surface, ground, or municipal water samples averaged 17 pCi/liter. The average gross beta radioactivity in water samples is well below the limitations imposed by the standard for gross beta radioactivity in drinking water (1,000 pCi/liter) (*1*). Only one treated water sample indicated gross alpha radioactivity greater than the minimum reported concentration.

Table 1. Gross alpha and beta radioactivity in Florida waters, 1968

Location subbasin	Number of samples	Alpha (pCi/liter)	Beta (pCi/liter)
Perdido-Escambia Rivers	4	7	10
	[a] 3	7	10
	[b] 1	7	24
Choctawhatchee River	12	7	10
	1	7	34
Apalachicola River	4	7	10
	[a] 5	7	10
Ochlockonee-St. Marks Rivers	5	7	10
	1	7	12
	[a] 2	7	10
	[c] 1	7	14
Suwannee River	5	7	10
	[a] 1	7	10
St. Mary's-Nassau Rivers	1	7	10
	[b] 1	7	10
St. John's River	37	7	10
	1	7	13
	1	7	15
	[a] 10	7	10
	[b] 4	7	10
	[c] 2	7	10
Withlacoochee River	9	7	10
	[b] 1	7	10
Tampa Bay area	9	7	10
	[a] 18	7	10
Peace River	2	7	10
	[a] 6	7	10
Kissimmee River	3	7	10
Florida East Coastal area	6	7	10
	[a] 7	7	10
	[c] 3	7	10
Lower Florida area	12	7	10
	2	7	13
	[a] 41	7	10
	[a] 1	9	10
	[b] 1	7	10

[a] Treated water.
[b] Well water.
[c] Raw water supply.

REFERENCE

(*1*) PUBLIC HEALTH SERVICE. Public Health Service Drinking Water Standards, Revised 1962, PHS Publication No. 956. Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (March (1963).

SECTION III. AIR AND DEPOSITION

Radioactivity in Airborne Particulates and Precipitation

Continuous surveillance of radioactivity in air and precipitation provides one of the earliest indications of changes in environmental fission product radioactivity. To date, this surveillance has been confined chiefly to gross beta radioanalysis. Although such data are insufficient to assess total human radiation exposure from fallout, they can be used to determine when to modify monitoring in other phases of the environment.

Surveillance data from a number of programs are published monthly and summarized periodically to show current and long-range trends of atmospheric radioactivity in the Western Hemisphere. These include data from activities of the U.S. Public Health Service, the Canadian Department of National Health and Welfare, the Mexican Commission of Nuclear Energy, and the Pan American Health Organization.

In addition to those programs presented in this issue, the following programs were previously covered in *Radiological Health Data and Reports:*

Network	Period	Issue
Fallout in the United States and Other Areas, *HASL*	January–June 1968	October 1969
Plutonium in Airborne Particulates and Precipitation, *PHS*	July–September 1968	February 1970

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1. Radiation Alert Network
November 1969

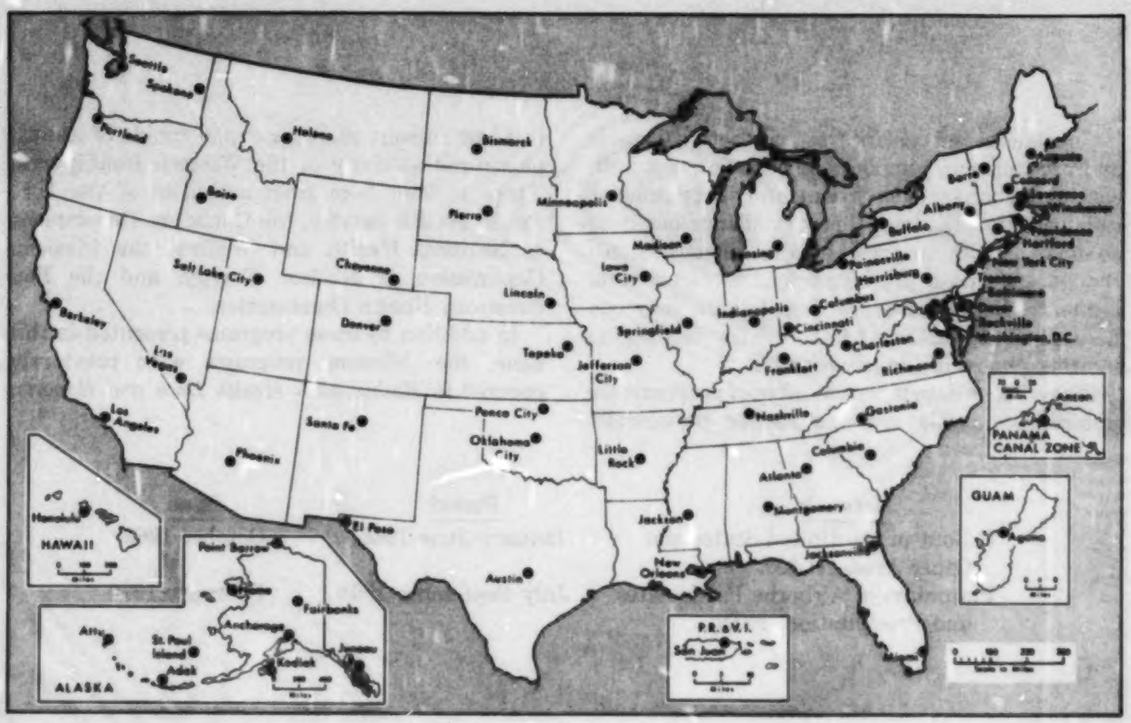
Bureau of Radiological Health
U.S. Public Health Service

Surveillance of atmospheric radioactivity in the United States is conducted by the Radiation Alert Network (RAN) which regularly gathers samples at 73 locations distributed throughout the country (figure 1). Most of the stations are operated by State health department personnel.

The station operators perform "field estimates" on the airborne particulate samples at 5 hours after collection, when most of the radon daughter products have decayed, and at 29 hours after collection, when most of the thoron daughter products have decayed. They also perform field estimates on dried precipitation samples and report all results to appropriate Bureau of Radiological Health officials by mail or telephone depending on levels found. A compilation of the daily field estimates is available upon request from the Radiological Surveillance Branch, Division of Environmental Radiation, BRH, Rockville, Md. A detailed description of the sampling and analytical procedures was presented in the March 1968 issue of *Radiological Health Data and Reports.*

Table 1 presents the monthly average gross beta radioactivity in surface air particulates and deposition by precipitation, as measured by the field estimate technique during November 1969. Time profiles of gross beta radioactivity in air for eight Radiation Alert Network stations are shown in figure 2.

All field estimates reported were within normal limits for the reporting stations.



Seattle
Spokane
Portland
Helena
Bismarck
Boise
Pierre
Minneapolis
Madison
Lansing
Salt Lake City
Cheyenne
Lincoln
Iowa City
Berkeley
Denver
Topeka
Las Vegas
Springfield
Indianapolis
Columbus
Cincinnati
Jefferson City
Frankfort
Charleston
Richmond
Buffalo
Painesville
Harrisburg
Albany
Barre
Augusta
Concord
Lawrence
Winchester
Providence
Hartford
New York City
Trenton
Baltimore
Dover
Rockville
Washington, D.C.
Los Angeles
Santa Fe
Ponca City
Oklahoma City
Nashville
Gastonia
Phoenix
Little Rock
Columbia
Atlanta
Montgomery
Jackson
El Paso
Austin
New Orleans
Jacksonville
Miami
Honolulu
HAWAII
Point Barrow
Nome
Fairbanks
Anchorage
Attu
St. Paul Island
Adak
Kodiak
Juneau
ALASKA
P.R. & V.I.
San Juan
Ancon
PANAMA CANAL ZONE
GUAM
Agana
0
100
200
300
Scale in Miles

Figure 1. Radiation Alert Network sampling stations

Table 1. Gross beta radioactivity in surface air and precipitation, November 1969

Station location		Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Last profile in RHD&R	Precipitation				
							Number of samples	Total depth (mm)	Field estimation of deposition		
			Maximum	Minimum	Average[a]				Number of samples	Depth (mm)	Total deposition (nCi/m²)
Ala:	Montgomery	18	7	0	4	Dec 69	3	15	3	15	0
Alaska:	Adak	17	1	0	1	Dec 69	(c)				
	Anchorage	15	0	0	0	Aug 69	(c)				
	Attu Island	15	0	0	0	Jan 70	(c)				
	Fairbanks	17	0	0	0	Sept 69	4	14	4	14	11
	Juneau	18	4	0	1	Oct 69	10	206	10	206	0
	Kodiak	8	0	0	0	Nov 69	(c)				
	Nome	27	1	0	1	Mar 70	(c)				
	Pt. Barrow	10	0	0	0	Feb 70	(c)				
	St. Paul Island	(b)				June 69	(c)				
Ariz:	Phoenix	14	12	1	5	Oct 69	(c)				
Ark:	Little Rock	7	3	1	2	Aug 69	(c)				
Calif:	Berkeley	18	2	0	1	Nov 69	1	20	1	20	1
	Los Angeles	17	3	0	2	Mar 70	(c)				
C.Z:	Ancon	11	0	0	0	Nov 69	(c)				
Colo:	Denver	18	5	0	2	Nov 69	2	14	(d)		
Conn:	Hartford	18	1	0	0	Sept 69	10	122	10	122	2
Del:	Dover	18	2	0	1	July 69	(c)				
D.C:	Washington	22	0	0	0	Feb 70	(c)				
Fla:	Jacksonville	18	2	0	2	Aug 69	5	101	5	101	43
	Miami	16	2	0	0	Sept 69	6	28	3	19	0
Ga:	Atlanta	17	1	1	1	June 69	2	137	2	137	54
Guam:	Agana	(b)				July 69	(c)				
Hawaii:	Honolulu	25	1	0	0	Jan 70	2	29	(d)		
Idaho:	Boise	18	6	1	3	Jan 70	3	44	3	44	12
Ill:	Springfield	15	4	1	1	Feb 70	(c)				
Ind:	Indianapolis	(b)				June 69	(c)				
Iowa:	Iowa City	15	4	0	1	Nov 69	1	4	1	4	0
Kans:	Topeka	17	4	1	2	Aug 69	1	1	1	1	1
Ky:	Frankfort	13	4	1	2	Feb 70	(c)				
La:	New Orleans	15	1	0	0	Feb 70	4	52	(d)		
Maine:	Augusta	18	1	0	1	Mar 70	13	219	13	219	0
Md:	Baltimore	18	1	0	1	Sept 69	6	43	6	43	5
	Rockville	11	2	0	1	Jan 70	(c)				
Mass:	Lawrence	16	2	0	0	Nov 69	8	183	8	183	8
	Winchester	19	2	0	0	Dec 69	10	235	10	235	0
Mich:	Lansing	18	2	0	1	Jan 70	7	28	7	28	3
Minn:	Minneapolis	16	1	0	1	July 69	2	42	2	42	2
Miss:	Jackson	18	5	0	1	Mar 70	2	45	2	45	6
Mo:	Jefferson City	20	3	0	1	June 69	4	23	4	23	0
Mont:	Helena	19	3	0	1	Dec 69	(c)				
Nebr:	Lincoln	8	7	1	3	June 69	(c)				
Nev:	Las Vegas	13	2	0	1	Sept 69	(c)				
N.H:	Concord	10	3	0	1	Feb 70	1	10	(e)		
N.J:	Trenton	16	1	0	0	Mar 70	6	54	6	54	2
N.Mex:	Santa Fe	9	2	0	1	Dec 69	(c)				
N.Y:	Albany	5	1	0	0	June 69	3	21	3	21	2
	Buffalo	16	1	0	0	Nov 69	(c)				
	New York City	17	1	0	0	Dec 69	(c)				
N.C:	Gastonia	14	8	0	4	Nov 69	3	18	(d)		
N.Dak:	Bismarck	18	7	1	3	Feb 70	(c)				
Ohio:	Cincinnati	(b)				July 69	(c)				
	Columbus	1	1	1	1	Mar 70	1	10	(e)		
	Painesville	20	1	0	1	Sept 69	11	79	11	79	0
Okla:	Oklahoma City	13	4	1	2	Jan 70	(c)				
	Ponca City	20	9	1	3	Sept 69	(c)				
Ore:	Portland	19	1	0	1	June 69	7	107	7	107	6
Pa:	Harrisburg	21	1	0	1	June 69	(c)				
P.R:	San Juan	(b)				Mar 70	(c)				
R.I:	Providence	17	2	0	0	Jan 70	7	133	7	133	19
S.C:	Columbia	16	8	0	3	Dec 69	(c)				
S.Dak:	Pierre	13	16	1	6	Oct 69	(c)				
Tenn:	Nashville	16	3	0	1	Jan 70	4	63	4	63	0
Tex:	Austin	13	6	1	4	July 69	1	7	(d)		
	El Paso	(b)				Feb 70	(c)				
Utah:	Salt Lake City	29	5	0	2	Mar 70	4	19	4	19	5
Vt:	Barre	15	6	0	1	Aug 69	8	131	8	131	48
Va:	Richmond	16	2	0	0	Aug 69	4	77	4	77	14
Wash:	Seattle	3	0	0	0	Aug 69	7	44	(d)		
	Spokane	17	5	1	3	July 69	(c)				
W.Va:	Charleston	8	2	0	1	Dec 69	3	38	3	38	5
Wisc:	Madison	19	2	0	1	Aug 69	5	18	5	18	3
Wyo:	Cheyenne	18	4	0	1	Sept 69	1	415	1	415	0
Network summary		1,050	16	0	1		6	92	5	86	8

[a] The monthly average is calculated by weighting the field estimates of individual air samples with length of sampling period.
[b] No report received. (Air samples received without field estimate data are not considered by the data program.)
[c] No precipitation sample collected.
[d] This station is part of the plutonium in precipitation network. No gross beta measurements are done.
[e] Samples were collected but no field estimates were received.

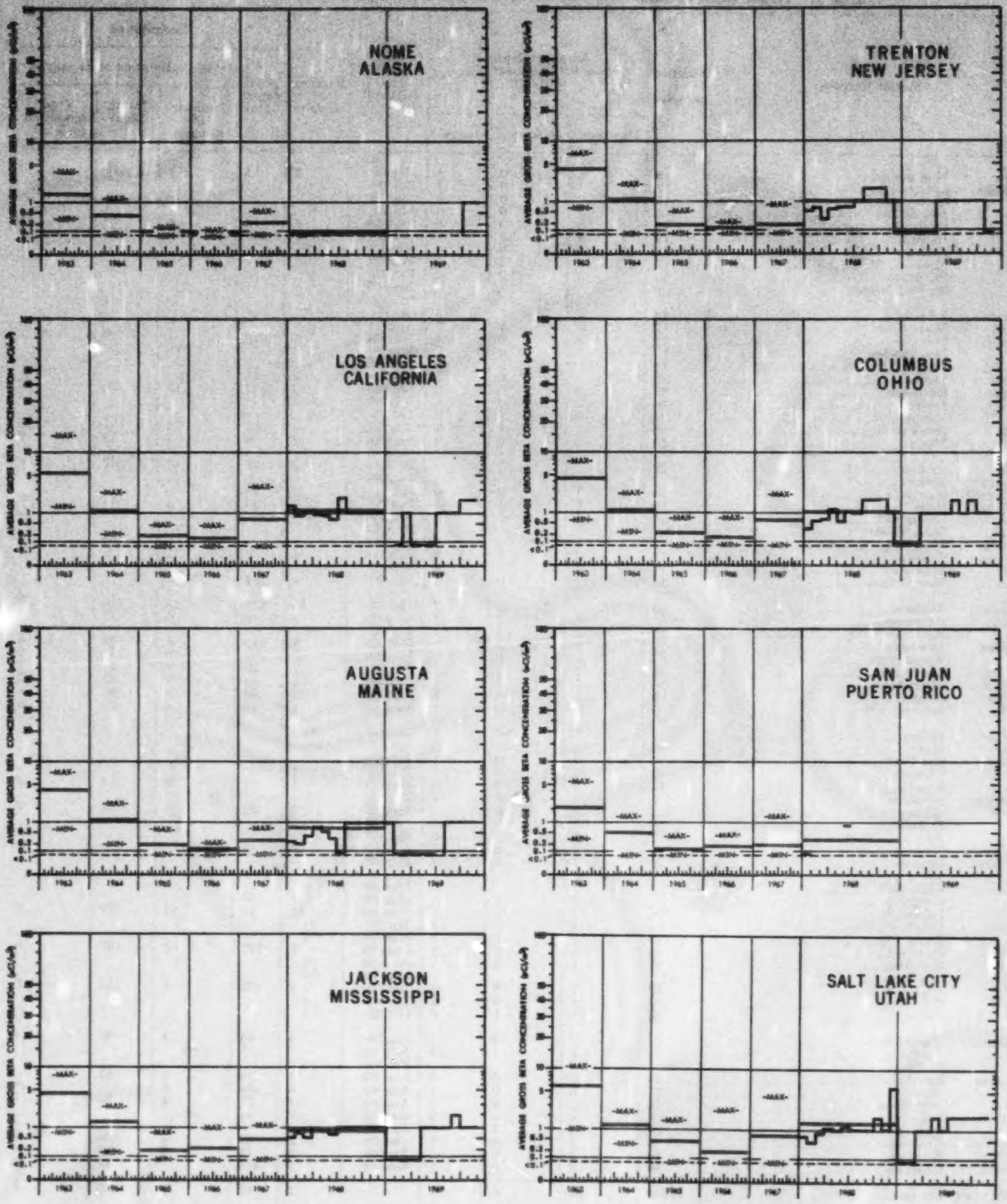


Figure 2. Monthly and yearly profiles of beta radioactivity in air—Radiation Alert Network, 1963–November 1969

2. Canadian Air and Precipitation Monitoring Program[1], November 1969

Radiation Protection Division
Department of National Health and Welfare

The Radiation Protection Division of the Canadian Department of National Health and Welfare monitors surface air and precipitation in connection with its Radioactive Fallout Study Program. Twenty-four collection stations are located at airports (figure 3), where the sampling equipment is operated by personnel from the Meterological Services Branch of the Department of Transport. Detailed discussions of the sampling procedures, methods of analysis, and interpretation of results of the radioactive fallout program are contained in reports of the Department of National Health and Welfare (*1–5*).

A summary of the sampling procedures and methods of analysis was presented in the May 1969 issue of *Radiological Health Data and Reports*.

Surface air and precipitation data for November 1969 are presented in table 2.

Table 2. Canadian gross beta radioactivity in surface air and precipitation, November 1969

Station	Number of samples	Air surveillance gross beta radioactivity (pCi/m³)			Precipitation measurements	
		Maximum	Minimum	Average	Average concentration (pCi/liter)	Total deposition (nCi/m²)
Calgary	29	0.1	0.0	0.1	NA	NA
Coral Harbour	26	.1	.0	.1	NA	NA
Edmonton	24	.1	.0	.1	36	0.7
Ft. Churchill	28	.1	.0	.1	23	.9
Ft. William	29	.1	.0	.1	39	1.1
Fredericton	30	.1	.0	.0	13	1.5
Goose Bay	30	.1	.0	.0	22	2.0
Halifax	30	.1	.0	.0	11	1.7
Inuvik	20	.1	.0	.1	108	.7
Montreal	29	.1	.0	.1	8	.9
Moosonee	29	.1	.0	.1	17	.8
Ottawa	29	.1	.0	.1	17	1.7
Quebec	30	.1	.0	.0	15	1.7
Regina	30	.1	.0	.1	147	.4
Resolute	26	.2	.0	.1	48	.2
St. John's, Nfld	28	.1	.0	.1	13	2.2
Saskatoon	28	.1	.0	.1	30	.3
Saulte Ste Marie	28	.1	.0	.1	32	2.3
Toronto	28	.2	.0	.1	33	2.4
Vancouver	30	.1	.0	.0	25	2.3
Whitehorse	30	.1	.0	.0	56	.2
Windsor	30	.2	.0	.1	19	1.5
Winnipeg	30	.2	.1	.1	48	.4
Yellowknife	29	.1	.0	.1	18	.4
Network summary	680	0.2	0.0	0.1	36	1.2

NA, no analysis.

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[1] Prepared from information and data obtained from the Canadian Department of National Health and Welfare, Ottawa, Canada.

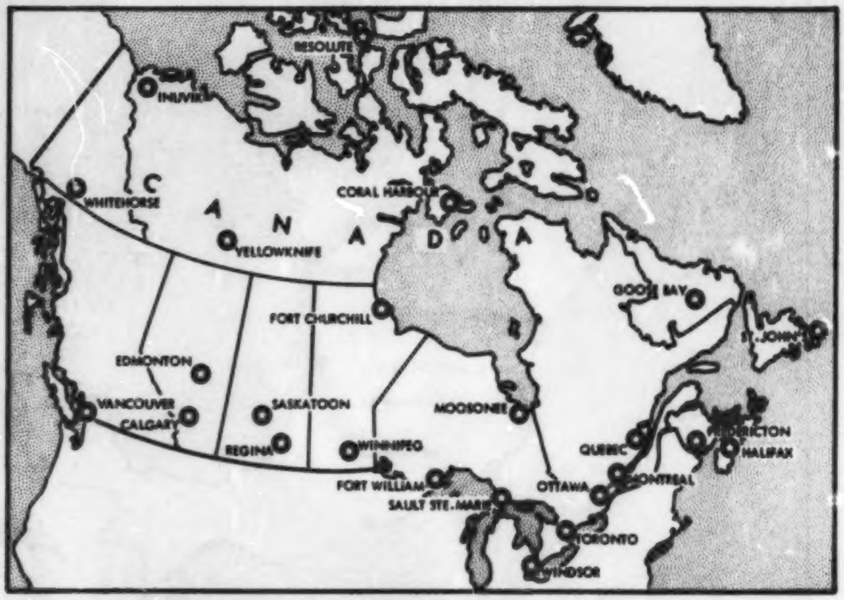
RESOLUTE
INUVIK
C A N A D A
WHITEHORSE
CORAL HARBOUR
YELLOWKNIFE
GOOSE BAY
FORT CHURCHILL
ST. JOHN'S
EDMONTON
MOOSONEE
VANCOUVER
CALGARY
SASKATOON
REGINA
WINNIPEG
QUEBEC
FREDERICTON
HALIFAX
OTTAWA
MONTREAL
FORT WILLIAM
SAULT STE. MARIE
TORONTO
WINDSOR

Figure 3. Canadian air and precipitation sampling stations

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3. Mexican Air Monitoring Program July and August 1969

National Commission of Nuclear Energy
México, D.F.

The Radiation Surveillance Network of Mexico was established by the Comisión Nacional de Energía Nuclear (CNEN), México, D.F. From 1952 to 1961, the network was directed by the Institute of Physics of the University of Mexico, under contract to the CHEN.

In 1961, the CNEN appointed its Division of Radiological Protection to establish a new Radiation Surveillance Network. In 1966, the Division of Radiological Protection was restructured and its name changed to Dirección General de Seguridad Radiológica (DRS). The network consists of 16 stations (figure 4), 11 of which are located at airports and operated by airline personnel. The remaining five stations are located at México, D.F.; Mérida; Veracruz; San Luis Potosí; and Ensenada. Staff members of the DRS operate the station at México, D.F., while the other four stations are manned by members of the Centro de Prevision del Golfo de Mexico, the Chemistry Department of the University of Mérida, the Institute de Zonas Desérticas of the University of San Luis Potosí, and the Escuela Superior de Ciencias Marinas of the University of Baja California, respectively.

Sampling

The sampling procedure involves drawing air through a high-efficiency, 6-by 9-inch glass-fiber filter for 20 hours a day, 3 or 4 days a week at the rate of 1,000 cubic meters per day using high volume samplers.

After each 20-hour sampling period, the filter is removed and shipped via airmail to the Sección de Radioactividad Ambiental, CNEN, in México, D.F., for assay of gross beta radioactivity, allowing a minimum of 3 or 4 days after collection for the decay of radon and thoron daughters. The data are not extrapolated to the time of collection. Statistically, it has been found that a minimum of five samples per month were needed to get a reliable average radioactivity at each station (*1*).

The maximum, minimum, and average beta radioactivity in surface air during July and August 1969 are presented in tables 3 and 4.

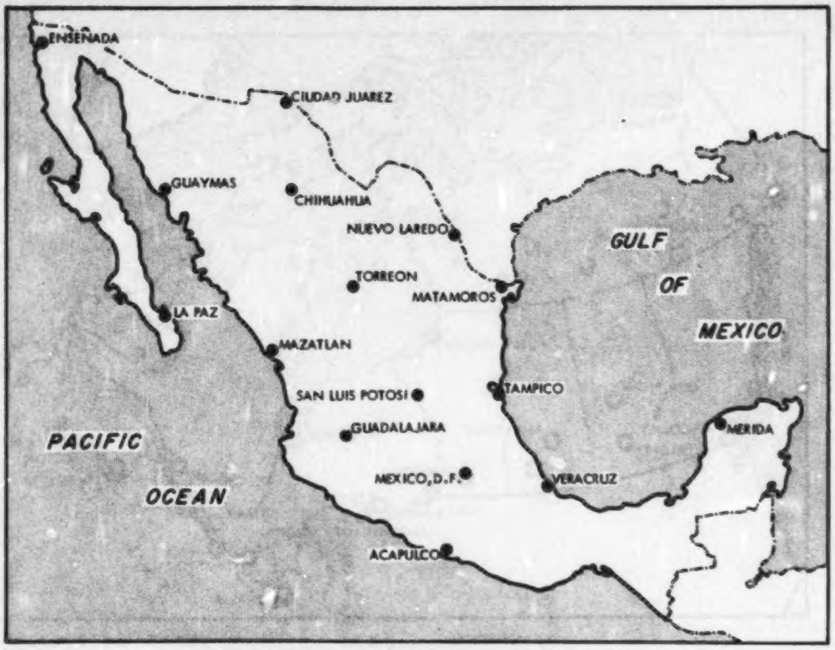

Figure 4. Mexican air sampling locations

Table 3. Mexican gross beta radioactivity of airborne particulates, July 1969

Station	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	15	0.9	0.1	0.4
Ciudad Juárez	6	.8	.2	.5
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	5	.7	.3	.5
Matamoros	NS			
Mazatlán	NS			
Mérida	12	.5	.1	.3
México, D.F.	4	.3	.1	.1
Nuevo Laredo	6	.6	.1	.3
San Luis Potosí	NS			
Tampico	NS			
Torreón	14	1.1	.1	.4
Veracruz	3	.6	.2	.2

NS, no sample, station temporarily shutdown.

Table 4. Mexican gross beta radioactivity of airborne particulates, August 1969

Station location	Number of samples	Gross beta radioactivity (pCi/m³)		
		Maximum	Minimum	Average
Acapulco	NS			
Chihuahua	16	0.4	0.1	0.2
Ciudad Juárez	11	.5	.1	.2
Ensenada	NS			
Guadalajara	NS			
Guaymas	NS			
La Paz	9	2.3	.1	.5
Matamoros	NS			
Mazatlán	NS			
Mérida	15	.2	.1	.1
México, D.F.	4	.1	.1	.1
Nuevo Laredo	NS			
San Luis Potosí	NS			
Tampico	NS			
Torreón	9	.5	.1	.1
Veracruz	7	.2	.1	.1

NS, no sample, station temporarily shutdown.

4. Pan American Air Sampling Program November 1969

Pan American Health Organization and *U.S. Public Health Service*

Gross beta radioactivity in air is monitored by countries in the Americas under the auspices of the collaborative program developed by the Pan American Health Organization (PAHO) and the U.S. Public Health Service (PHS) to assist PAHO-member countries in developing radiological health programs.

The air sampling station locations are shown in figure 5. Analytical techniques were described in the January 1968 issue of *Radiolgical Health Data and Reports*. The November 1969 air monitoring results from the participating countries are given in table 5.

Table 5. Summary of gross beta radioactivity in Pan American surface air, November 1969

Station location		Number of samples	Gross beta radioactivity (pCi/m³)		
			Maximum	Minimum	Average[a]
Argentina:	Buenos Aires	13	0.16	0.07	0.11
Bolivia:	La Paz	14	.10	.00	.05
Chile:	Santiago	29	.23	.05	.10
Colombia:	Bogota	19	.08	00	.02
Ecuador:	Cuenca	NS			
	Guayaquil	3	.06	.02	.04
	Quito	NS			
Guyana:	Georgetown	NS			
Jamaica:	Kingston	17	.12	.01	.03
Peru:	Lima	NS			
Venezuela:	Caracas	19	.03	.00	.01
West Indies:	Trinidad	18	.04	.00	.01
Pan American summary		132	0.23	0.00	0.05

[a] The monthly average is calculated by weighting the individual samples with length of sampling period. Values less than 0.005 pCi/m³ are reported and used in averaging as 0.00 pCi/m³.

NS, no sample.

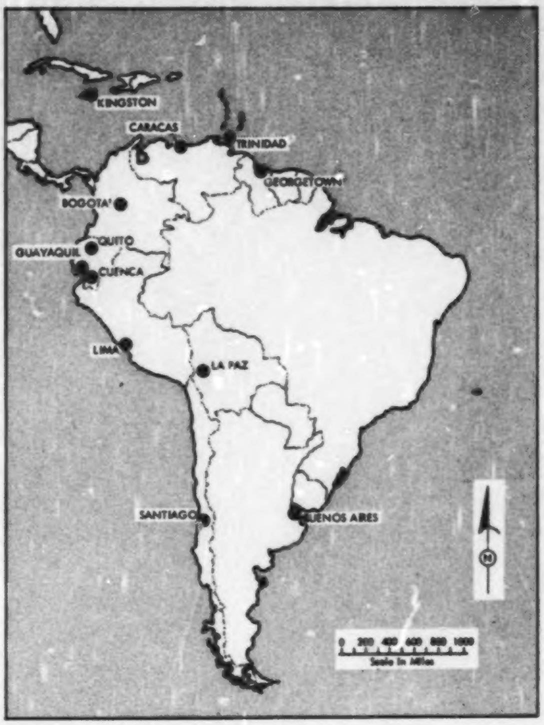

Figure 5. Pan American Air Sampling Program stations

REFERENCES

(1) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report of 1959 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (May 1960).

(2) BIRD, P. M., A. H. BOOTH, and P. G. MAR. Annual report for 1960 on the Radioactive Fallout Study Program, CNHW-RP-3. Department of National Health and Welfare, Ottawa, Canada (December 1961).

(3) MAR, P. G. Annual report for 1961 on the Radioactive Fallout Study Program, CNHW-RP-5. Department of National Health and Welfare, Ottawa, Canada (December 1962).

(4) BEALE, J. and J. GORDON. The operation of the Radiation Protection Division Air Monitoring Program, RPD-11. Department of National Health and Welfare, Ottawa, Canada (July 1962).

(5) BOOTH, A. H. The calculation of permissible levels of fallout in air and water and their use in assessing the significance of 1961 levels in Canada, RPD-21. Department of National Health and Welfare, Ottawa, Canada (August 1962).

(6) VASQUEZ, M. and R. M. DE NULMAN. Estudios sobre la radioactividad ambiental en la Republica Méxicana, 1963–1965. Comisión Nacional de Energía Nuclear, Dirección General de Seguridad Radiologica (1966).

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SECTION IV. OTHER DATA

This section presents results from routine sampling of biological materials and other media not reported in the previous sections. Included here are such data as those obtained from human bone sampling, Alaskan surveillance and environmental monitoring around nuclear facilities.

Offsite Surveillance Around the Nevada Test Site,[1] July-December 1965

Southwestern Radiological Health Laboratory,
DHEW, and *Nevada Operations Office, AEC*

Under a Memorandum of Understanding between the U.S. Atomic Energy Commission (AEC), and the Public Health Service, the Southwestern Radiological Health Laboratory (SWRHL) of the Bureau of Radiological Health performed radiological surveillance in the offsite area surrounding the Nevada Test Site (NTS) during the period from July through December 1965. During this period, nine announced underground nuclear tests were conducted at the NTS and one was conducted on Amchitka Island in the Aleutian Chain. This latter underground test was part of the Vela Uniform program and offsite coverage was provided by the SWRHL.

Operational procedures, NTS

Both ground and aerial monitoring capabilities were maintained throughout the period. Mobile ground monitoring teams were positioned in offsite areas prior to each event and an aerial monitoring team was prepared to track any radioactive releases to determine relative radiation intensities and to indicate cloud position, speed, and direction. Monitoring teams were equipped with

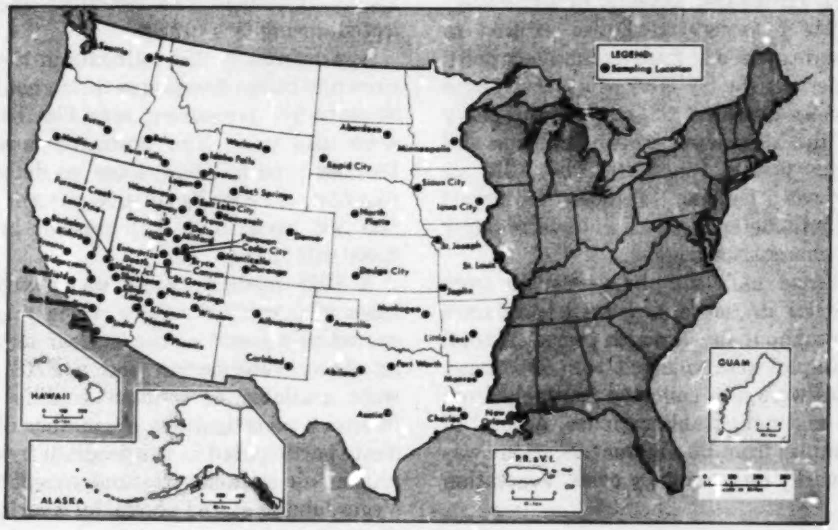
LEGEND:
● Sampling Location
Medford
Boise
Twin Falls
Idaho Falls
Worland
Logan
Rock Springs
Salt Lake City
Denver
Cedar City
Monticello
Durango
St. George
Kingman
Phoenix
Albuquerque
Carlsbad
Aberdeen
Minneapolis
Rapid City
Sioux City
Iowa City
North Platte
St. Joseph
St. Louis
Dodge City
Joplin
Muskogee
Amarillo
Little Rock
Abilene
Fort Worth
Monroe
Austin
Lake Charles
New Orleans
HAWAII
ALASKA
GUAM
P.R. & V.I.

Figure 1. Air surveillance network stations other than Nevada

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[1] Summarized from Report No. SWRHL-24r (*1*).

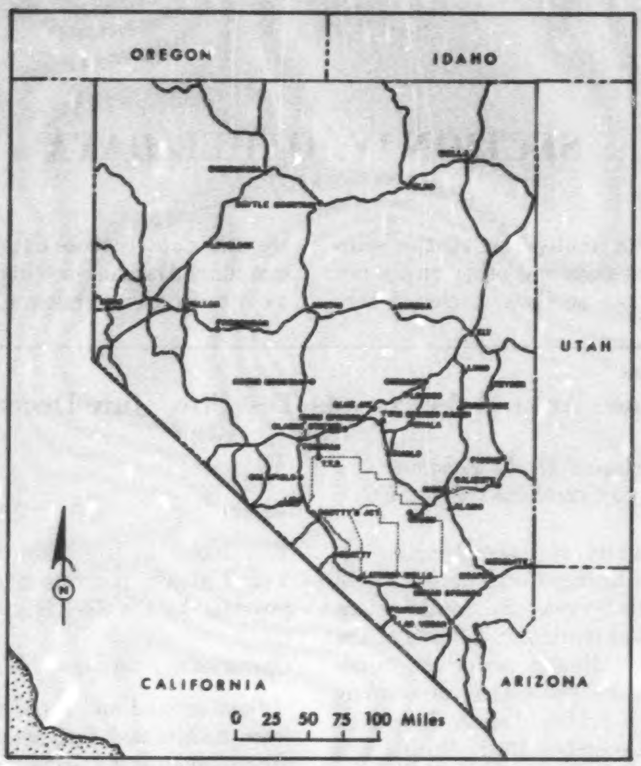

Figure 2. Air surveillance network stations in Nevada

Eberline E-500B, Precision Model 111 Standard "Scintillator," Beckman MX-5, and Tracerlab AN/PDR T1B survey instruments. Eberline RM-11 gamma rate recorders were also utilized to document cloud passage at fixed ground locations. During this period, the SWRHL Air Surveillance Network (ASN) operated 98 stations in every State west of the Mississippi except Montana and North Dakota (figures 1 and 2). The ASN air sampler used was a Gelman "Tempest" equipped to use a 4-inch diameter Whatman 541 filter paper and an MSA[2] charcoal cartridge.

The established milk sampling program from both commercial dairies and private producers continued throughout the 6-month period. A total of 204 milk samples were collected from 59 sources. Water samples were also collected routinely from both potable and nonpotable supplies. A total of 218 water samples from 63 different locations was collected primarily on a monthly basis. Vegetation samples, the results of which are used to delineate any fallout pattern, are collected only after a known release of radioactivity; none were collected during this period.

Approximately 150 residents in the offsite area wore film badge dosimeters throughout this period. Seventy-five permanent area film badge stations were also used. The dosimeter used contained DuPont type 555 film. Dose, as determined from this film, is accurate to ±50 percent in the 20 to 100 mR range and ±10 percent in the 100 to 2,000 mR range.

A PHS medical officer was available for any cases of a medical nature which might have occurred as a result of the nuclear tests. Similarly, an Army veterinarian and a PHS veterinarian were available to conduct wildlife or domestic livestock investigations. A number of offsite residents participated in the program by operating all routine air sampling stations except those in Las Vegas, and as stated above, by wearing film badge dosimeters.

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[2] Mine Safety Appliance Co.

Operational procedures—Amchitka Island

On the day of the event (October 29, 1965) named Project Longshot, nine monitors were standing by on three other islands in the Aleutian Chain and on the Alaskan Mainland. Additionally, one PHS staff member was at the Amchitka control point and three PHS personnel were airborne in a USAF C–54 aircraft in the Amchitka area. A PHS medical officer was stationed on a U.S. Coast Guard cutter which was patrolling in the vicinity of Amchitka Island.

Each monitor was equipped with an Eberline E–500B survey instrument and a Victoreen Radector Model AGB–50B–SR.

Nineteen air sampling stations were established during October in the Aleutian Islands and at other Alaskan locations. These Alaskan stations operated through October and in some cases, into November (figure 3).

On the day of the event, 16 thermoluminescent dosimeters and 25 film badges were placed at stations or were worn by ten PHS personnel.

No milk, water, or vegetation samples were collected specifically for this event.

Analytical procedures

Samples were returned to the SWRHL in Las Vegas for radiological analysis. Air sample particulate filters from the NTS and Amchitka Island networks were beta counted in a Beckman wide-beta, low-background, proportional counter system. Selected filters, all charcoal cartridges, and water and milk samples were analyzed for gamma-ray-emitting radionuclides using a 4- by 4-inch NaI(Tl) crystal coupled to a TMC Model 404C gamma pulse-height analyzer. The lower limit of detection for gamma-ray emitters in milk samples was 20 pCi/liter at the time of count. Gamma-ray spectra were evaluated using a matrix technique which allowed for the simultaneous determination of eight nuclides.

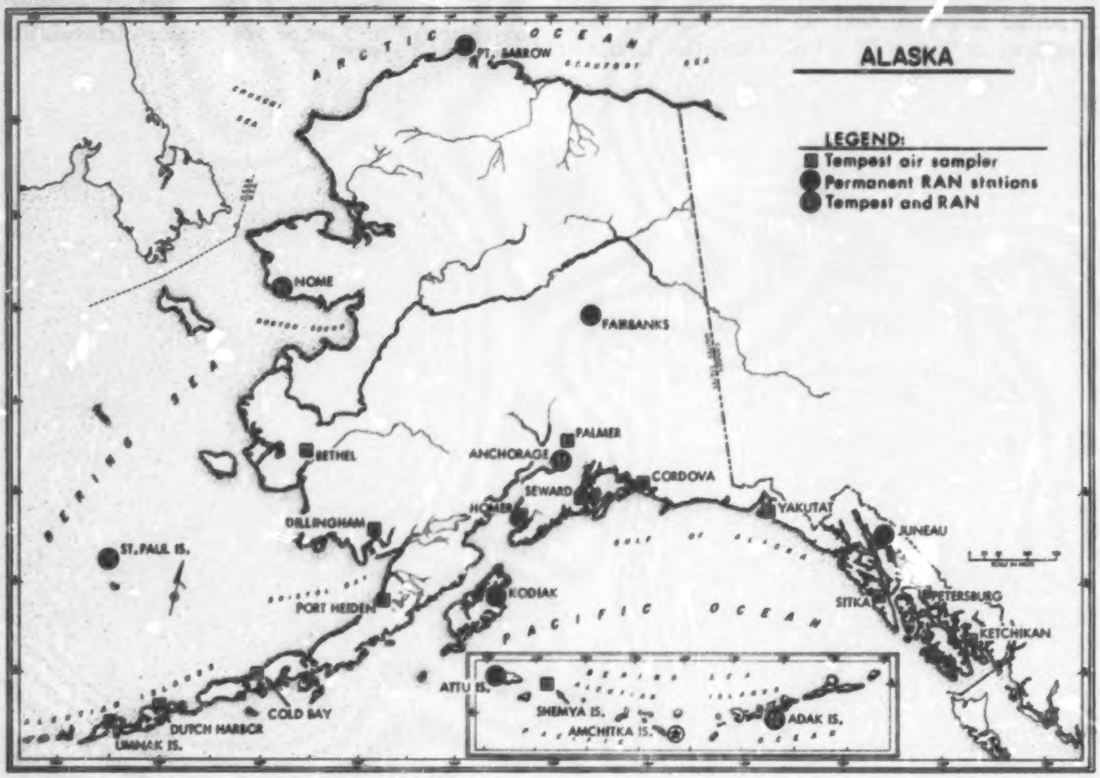
ALASKA
LEGEND:
■ Tempest air sampler
● Permanent RAN stations
● Tempest and RAN
ARCTIC OCEAN
PT. BARROW
BEAUFORT SEA
CHUKCHI SEA
NOME
NORTON SOUND
FAIRBANKS
BERING SEA
BETHEL
PALMER
ANCHORAGE
CORDOVA
SEWARD
HOMER
YAKUTAT
JUNEAU
DILLINGHAM
ST. PAUL IS.
GULF OF ALASKA
KODIAK
BRISTOL BAY
PORT HEIDEN
PACIFIC OCEAN
SITKA
PETERSBURG
KETCHIKAN
ATTU IS.
SHEMYA IS.
AMCHITKA IS.
ADAK IS.
BERING SEA
ALEUTIAN ISLANDS
COLD BAY
DUTCH HARBOR
UMNAK IS.

Figure 3. Air sampling stations in the Aleutian Islands and other Alaskan locations

Results

No radioactive effluent was detected in offsite populated areas as a result of any nuclear test conducted during this period at NTS or in Alaska. A few milk samples collected north of the NTS in early July contained iodine-131; however, the activity in these samples is attributed to the Phoebus 1A reactor experiment which was conducted at the Nuclear Rocket Development Station (NRDS) on June 25, 1965. The results of this Phoebus experiment were published in SWRHL-19r (*2*) and SWRHL-23r (*3*). Two milk samples collected in September and one collected in October also contained iodine-131; the values, however, were at or near the detection limit for this nuclide (20 pCi/liter) and cannot be attributed to any nuclear test release, foreign or domestic.

Conclusions

Environmental radiation surveillance during this period indicates that no individual in the offsite area of the NTS or of Amchitka Island received an exposure, as a result of nuclear test activities, which exceeded the guides established by the AEC or recommended by the Federal Radiation Council.

REFERENCES

(*1*) PUBLIC HEALTH SERVICE, SOUTHWESTERN RADIOLOGICAL HEALTH LABORATORY. Offsite Surveillance Activities of the Southwestern Radiological Health Laboratory from July through December 1965, Report No. SWRHL-24r. Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151 (May 23, 1966).

(*2*) PUBLIC HEALTH SERVICE, SOUTHWESTERN RADIOLOGICAL HEALTH LABORATORY. Final Report of Offsite Surveillance for the Phoebus 1A Experiment, Report No. SWRHL-19r. Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

(*3*) PUBLIC HEALTH SERVICE, SOUTHWESTERN RADIOLOGICAL HEALTH LABORATORY. Offsite Surveillance Activities of the Southwestern Radiological Health Laboratory from January through June 1965, Report No. SWRHL-23r. Available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151.

Strontium-90 in Human Bone,[1] January-March 1969

Bureau of Radiological Health
U.S. Public Health Service

To obtain data on the concentration of strontium-90 in man by age and geographical region, the Public Health Service began collecting human bone specimens in late 1961. Analyses of selected samples of people in older-age groups have shown their bone strontium-90 content to be low and age-independent (*1*). Consequently, the target population includes children and young adults up to 25 years of age.

Although a few samples come from living persons as a result of surgical procedures, the majority are obtained post mortem. In the latter case, the specimens are limited to accident victims or persons who have died of an acute disease process that was not likely to impair bone metabolism. For analytical purposes, a sample of at least 100 grams of wet bone is desired. Generally, this amount is readily available from older children, but it presents some difficulties from the standpoint of infants and children under 5 years of age. Most specimens received to date have been vertebrae and ribs.

Laboratory procedures

The bones are analyzed at Northeastern Radiological Health Laboratory of the Bureau of Radiological Health, at Winchester, Mass. Sample collection and preparation are explained elsewhere (*2*). Strontium-90 is measured by tributyl phosphate extraction of its yttrium daughter, which is precipitated as an oxalate. The strontium-90 content is then calculated (*3*) from the yttrium-90 activity. For the purpose of maintaining analytical reproducibility, "blind" duplicate analyses are performed on 10 to 20 percent of the samples.

The analytical results for strontium-90 in individual bones from persons dying during the first quarter (January-March) of 1969 are presented in table 1 in order of increasing age within each geographical region. These regions are indicated in figure 1. Reported values are given in picocuries

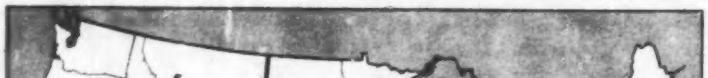

Figure 1. Geographical regions for human bone sampling

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[1] Period during which death or surgical procedure occurred.

Table 1. Strontium-90 in human bone, January–March 1969

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	^{90}Sr/Ca (pCi/g)
Northeast:						
Massachusetts	V	00	M	55.6 ± 6.9	30.4	1.82
New York	V	1	M	40.6 ± 6.0	23.9	1.70
Massachusetts	V	2	M	158.0 ± 13.0	33.7	4.67
Vermont	V	2	M	155.0 ± 13.0	31.0	5.00
New York	V	2	F	84.9 ± 7.9	23.3	3.64
	V	2	M	79.6 ± 8.8	33.9	2.35
	V	2	F	53.1 ± 6.2	19.6	2.70
Massachusetts	V	2	M	145.0 ± 12.0	38.7	3.74
New York	V	2	M	66.3 ± 7.3	29.2	2.27
	V	3	F	53.5 ± 6.8	21.9	2.44
Massachusetts	V	5	F	187.0 ± 11.0	33.2	5.63
	V	6	M	113.0 ± 13.0	27.6	4.09
New York	V	6	F	104.0 ± 9.5	43.5	2.39
	V	7	M	31.9 ± 7.2	23.7	1.34
Vermont	V	8	M	61.3 ± 9.3	30.4	2.01
Massachusetts	V	9	F	109.0 ± 8.9	30.4	3.58
New York	V	9	M	58.6 ± 7.4	31.0	1.89
	V	10	M	77.1 ± 7.4	39.2	1.96
Massachusetts	V	11	M	113.0 ± 11.0	47.6	2.37
	V	13	F	70.6 ± 5.6	29.5	2.39
	V	13	M	108.0 ± 11.0	32.7	3.30
New York	V	15	F	85.1 ± 7.3	37.9	2.24
	V	15	M	44.5 ± 6.2	40.9	1.09
Rhode Island	V	16	M	121.0 ± 9.4	44.8	2.70
New York	V	16	M	105.0 ± 8.8	38.7	2.71
Massachusetts	V	18	M	150.0 ± 12.0	47.0	3.19
	V, R	19	M	55.4 ± 7.3	31.9	1.73
Rhode Island	V, S	19	M	70.1 ± 6.9	30.3	2.3[illegible]
Massachusetts	V	19	M	120.0 ± 11.0	37.0	3.24
New York	V	22	F	113.0 ± 8.8	50.4	2.24
Southeast:						
Maryland	V	0	M	68.2 ± 8.2	41.3	1.65
	V	0	M	80.0 ± 10.0	39.7	2.01
Delaware	V	8	M	50.8 ± 6.8	31.8	1.59
South Carolina	V	11	F	141.0 ± 11.0	37.3	3.78
Maryland	V	11	F	132.0 ± 10.0	43.1	3.06
	V	11	M	81.3 ± 9.5	37.7	2.15
	V	14	F	105.0 ± 10.0	53.4	1.96
	V	14	M	89.8 ± 9.9	39.4	2.27
	V	16	M	130.0 ± 14.0	46.5	2.79
	V	17	M	111.0 ± 11.0	51.3	2.16
	V	17	M	96.3 ± 10.0	52.8	1.82
	V	17	M	106.0 ± 42.0	56.3	1.88
	V	18	M	132.0 ± 11.0	48.6	2.71
	V	18	M	103.0 ± 10.0	47.9	2.15
	V	18	M	180.0 ± 12.0	50.1	3.59
	V	19	M	71.9 ± 11.0	46.4	1.54
	V	21	F	92.3 ± 9.5	51.1	1.80
Central:						
Ohio	V	0	M	85.7 ± 12.0	31.4	2.72
Minnesota	V	3	F	103.0 ± 18.0	45.4	2.28
Ohio	V	5	M	80.0 ± 12.0	50.2	1.59
Michigan	V	5	F	60.6 ± 7.1	32.8	1.84
Ohio	V	7	M	37.5 ± 7.2	26.1	1.43
Wisconsin	V	8	F	54.8 ± 6.2	34.1	1.60
Ohio	V	8	M	110.0 ± 10.0	35.8	3.07
Michigan	V	9	M	83.1 ± 8.4	38.3	2.16
Ohio	V	9	M	80.8 ± 7.6	31.9	2.53
Michigan	V	10	M	95.2 ± 9.0	42.4	2.24
Wisconsin	V	10	F	54.4 ± 5.9	35.2	1.54
	V	10	M	70.3 ± 8.0	40.4	1.74
Ohio	V	12	M	81.3 ± 8.4	46.7	1.74
	V	12	M	98.7 ± 9.0	47.0	2.10
Iowa	V	12	M	88.6 ± 6.7	37.7	2.35
Ohio	V	13	F	142.0 ± 12.0	53.3	2.66
	V	14	M	73.5 ± 8.0	38.2	1.92
	V	14	M	91.2 ± 10.0	61.0	1.49
Iowa	V	14	M	50.2 ± 6.7	41.7	1.20
Ohio	V	14	M	76.5 ± 8.0	41.3	1.85
	V	15	F	121.0 ± 12.0	48.5	2.49
	V	16	F	104.0 ± 9.7	52.6	1.97
Michigan	V	17	M	71.8 ± 9.6	35.7	2.01
	V	17	M	208.0 ± 16.0	61.9	3.36
Ohio	V	18	M	97.0 ± 10.0	52.4	1.85
	V	18	F	104.0 ± 13.0	54.8	1.90
	V	18	M	115.0 ± 12.0	56.1	2.04
	V	19	F	124.0 ± 11.0	56.3	2.20
	V	19	F	177.0 ± 11.0	43.7	4.05
Minnesota	V	21	F	47.0 ± 8.1	31.5	1.49
Ohio	V	22	M	78.9 ± 9.3	50.8	1.55
	V	22	M	90.8 ± 11.0	52.4	1.73
	V	23	F	78.4 ± 8.8	55.7	1.40
	V	23	F	87.2 ± 9.6	55.5	1.57
	V	24	F	84.7 ± 7.5	53.8	1.57
	V	25	M	90.4 ± 9.8	54.5	1.65

See footnotes at end of table.

Table 1. Strontium-90 in human bone, January-March 1969—Continued

Bone region and State	Bone type[a]	Age[b] (years)	Sex	Strontium-90 concentration[c] (pCi/kg bone)	Calcium concentration (g/kg bone)	$^{90}Sr/Ca$ (pCi/g)
Northwest:						
Oregon	V	1	M	77.6 ± 9.0	31.3	2.47
	V	14	F	83.7 ± 12.0	56.4	1.48
Washington	V	17	M	91.0 ± 9.0	40.2	2.26
Oregon	V	18	M	85.5 ± 8.8	44.4	1.92
	V	19	M	106.0 ± 12.0	55.9	1.90
	V	19	F	120.0 ± 13.0	67.9	1.80
	V	20	M	62.4 ± 8.9	46.0	1.35
Washington	T	22	M	222.0 ± 15.0	207.0	1.07
Oregon	V	23	M	83.1 ± 9.7	54.9	1.51
Southwest:						
Colorado	V	6	M	83.5 ± 7.7	27.1	3.08
Utah	F	17	F	248.0 ± 13.0	152.0	1.63
Colorado	V	18	M	63.3 ± 7.9	44.6	1.41
	V	19	M	36.7 ± 7.9	47.3	.77
Utah	V	18	F	105.0 ± 11.0	55.8	1.88
Colorado	V	19	M	81.4 ± 8.4	55.9	1.45
	V	21	M	75.3 ± 7.5	50.4	1.49
	V	21	M	88.9 ± 12.0	52.7	1.68
Texas	V	21	M	66.7 ± 7.8	53.3	1.25
North:						
Alaska	R	15	F	314.0 ± 40.0	127.0	2.47
	V	25	M	76.0 ± 10.0	46.1	1.64

[a] Type of bone, V, vertebrae; R, rib; S, sternum; T, tibia; F, femur.
[b] Age given as of last birthday prior to death.
[c] Two-sigma counting error.

of strontium-90 per kilogram of bone (as a rough indication of dose) and per gram of calcium (for comparison with other data and for purposes of model development). Two-sigma counting errors are reported for the bone concentration.

Following the pattern of earlier reports, subsequent articles will continue to provide interpretation of the data at appropriate stages in the program (*2–5*).

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
July–September 1968	September 1969
October–December 1968	December 1969

REFERENCES

(*1*) RIVERA, J. Strontium-90 in human vertebrae, 1962–1963. Radiol Health Data 5:511–513 (October 1964).

(*2*) WEISS, E. S., W. H. LAND, K. H. FALTER, and R. M. HALLISEY. Strontium-90 content of human bones, 1961–1963. Radiol Health Data 5:231–239 (May 1964).

(*3*) PUBLIC HEALTH SERVICE, NORTHEASTERN RADIOLOGICAL HEALTH LABORATORY. Analysis of environmental samples, chemical and radiochemical procedures, NERHL 64-1. Northeastern Radiological Health Laboratory, Winchester, Mass. (April 1964).

(*4*) GAFFNEY, G. W., R. M. HALLISEY, M. S. MILLER, and A. S. GOLDIN. Strontium-90 in human bone, 1962–1963. Radiol Health Data 5:620–628 (December 1964).

(*5*) HALLISEY, R. M., and M. A. WALL. Strontium-90 in human bone, 1964–1965. Radiol Health Data Rep 8:415–419 (August 1967).

Environmental Levels of Radioactivity at Atomic Energy Commission Installations

The U.S. Atomic Energy Commission (AEC) receives from its contractors semiannual reports on the environmental levels of radioactivity in the vicinity of major Commission installations. The reports include data from routine monitoring programs where operations are of such a nature that plant environmental surveys are required.

Releases of radioactive materials from AEC installations are governed by radiation standards set forth by AEC's Division of Operational Safety in directives published in the "AEC Manual."[1]

Summaries of the environmental radioactivity data follow for the Atomics International and Feed Materials Production Center.

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[1] Title 10, Code of Federal Regulations, Part 20, "Standards for Protection Against Radiation" contains essentially the standards published in Chapter 0524 of the AEC Manual.

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1. Atomics International[2]
January–June 1969

North American Rockwell Corporation
Canoga Park, Calif.

Atomics International, a division of North American Rockwell Corporation, has been engaged in atomic energy research and development since 1946. The company designs, develops, and constructs nuclear reactors for central station and compact power plants for medical, industrial, and scientific applications.

The company headquarters is located in Canoga Park, California, approximately 23 miles northwest of downtown Los Angeles. The 290-acre Nuclear Development Field Laboratory (Santa Susana Facility), equipped with extensive testing facilities for the support of advanced nuclear studies, is in Ventura County in the Simi Hills approximately 29 miles northwest of downtown Los Angeles. The location of the above sites in relation to nearby communities is shown in figure 1.

The basic concept of radiological hazard control at Atomics International encourages total containment of radioactive materials and, through rigid operational controls, minimizes effluent releases and external radiation levels. The environmental monitoring program provides a check on the effectiveness of radiological safety procedures and of engineering safeguards incorporated into facility design.

The environs of Atomic International headquarters and Nuclear Development Field Laboratory (NDFL) are surveyed monthly to determine the concentration of radioactivity in typical surface soil, vegetation, and water samples. In addition, continuous environmental air monitoring at the sites provides information concerning airborne particulate radioactivity.

Air monitoring

Environmental air sampling is conducted continuously at the headquarters and NDFL sites with automatic air samplers operating on 24-hour sampling cycles. Airborne particulate radioactivity is collected on HV–70 filter paper which is automatically changed at the end of each sampling period. The filter is removed from the sampler and counted after the radioactivity is allowed to decay for at least 72 hours. The volume of a typical daily environmental air sample is approximately 20-cubic meters. The average concentration of long-lived beta-gamma radioactivity on airborne particulates is presented in table 1 for January–June 1969.

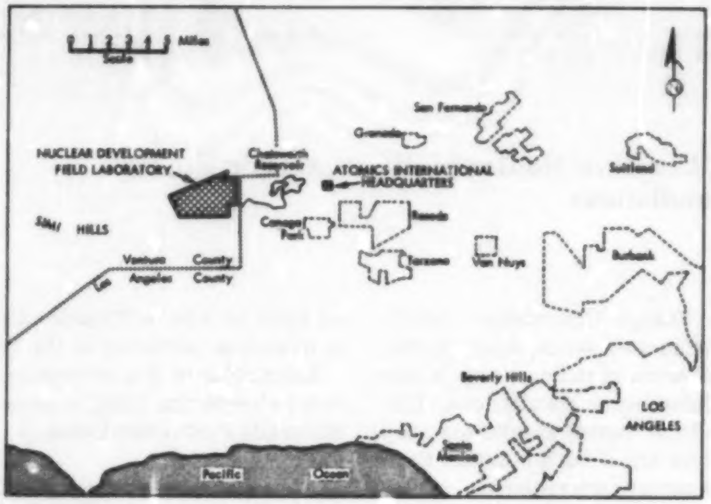
0 1 2 3 4 5 Miles
Scale
NUCLEAR DEVELOPMENT FIELD LABORATORY
Chatsworth Reservoir
ATOMICS INTERNATIONAL HEADQUARTERS
San Fernando
Granada
Sunland
SIMI HILLS
Canoga Park
Reseda
Tarzana
Van Nuys
Burbank
Ventura County
Los Angeles County
Beverly Hills
LOS ANGELES
Santa Monica
Pacific
Ocean

Figure 1. Atomics International facilities and vicinity

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[2] Summarized from "Environmental Monitoring, Semiannual Report, January 1, 1969 to June 30, 1969" Atomics International, Division of North American Rockwell Corporation.

Table 1. Beta-gamma radioactivity of airborne particulates, Atomics, January–June 1969

Location	Number of samples	Average concentration (pCi/m³)
Headquarters	262	0.25
NDFL	1,214	.24

When abnormally high airborne radioactivities are observed, the radioactivity decay data are plotted to determine the presence of short-lived isotopes other than naturally occurring radon, thoron, and daughters. If fall-out is suspected, the decay characteristics are observed. If the radioactivity decays as a function of $t^{-1.2}$, the data curve is extrapolated in order to determine the date of origin. This data is compared with the dates of publicized nuclear detonations to determine if the abnormal airborne radioactivity was caused by such detonations.

A graph of averaged long-lived airborne radioactivity concentrations detected at the headquarters and NDFL facilities during the first half of 1969 is presented in figure 2. The graph shows the incidence of five major peaks of extended duration during the reporting period, with a generally increasing trend through the spring months following a period of airborne radioactivity suppression by heavy rainfall during January and February.

Water monitoring

Process water used at the NDFL is obtained from Ventura County Water District No. 10 and distributed onsite by the same piping system previously used when process water was supplied by onsite wells. Pressure is provided by elevated storage tanks, one 50,000-gallon and one 500,000-gallon tank onsite. While clinically potable, the water is not used for drinking. Bottled potable water is delivered by a vendor and is not analyzed. Water from the pipe system is sampled monthly at two locations. The average process water radioactivity concentration is presented in table 2.

Table 2. Process water radioactivity, NDFL site January–June 1969

Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Alpha	12	0.16
Beta-gamma	12	4.4

Soil, vegetation, and water are sampled monthly at Chatsworth Reservoir which is operated by the Los Angeles City Department of Water and Power. Normally, one water sample is obtained from the lake surface and a second sample is obtained from the reservoir water supply inlet located on the north side of the lake. The average radioactivity for both surface and supply water samples is presented in table 3.

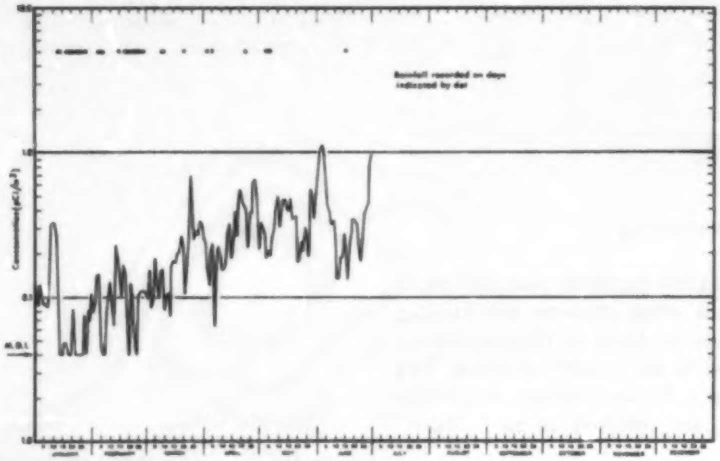

Figure 2. Long-lived airborne radioactivity at Atomics International, January–June 1969

Table 3. Chatsworth Reservoir water radioactivity Atomics, January–June 1969

Sample	Type of radioactivity	Number of samples	Average concentration (pCi/liter)
Lake surface	Alpha	6	0.35
	Beta-gamma	6	6.1
Supply inlet	Alpha	6	.15
	Beta-gamma	6	6.0

Surface discharged waters from NDFL facilities drain into holding reservoirs on adjacent property. When full, the main reservoir is drained into Bell Creek, a tributary of the Los Angeles River in the San Fernando Valley, Los Angeles County. Pursuant to the requirements of Los Angeles Regional Water Quality Control Board Resolution 66–49 of September 21, 1966, an environmental sampling station has been established in Bell Creek Canyon approximately 3.4 miles downstream from the south NDFL boundary. Samples, obtained and analyzed monthly, include stream bed mud, vegetation, and water. Average radioactivity concentrations in the main holding reservoir and Bell Creek samples are presented in table 4.

Table 4. Radioactivity in the Rocketdyne reservoir and Bell Creek[a], January–June 1969

Sample description (units)	Number of samples	Alpha radioactivity	Beta radioactivity
Reservoir station 6, water[a] (pCi/liter)	6	0.12	4.9
Reservoir station 12, water[a] (pCi/liter)	5	.15	4.5
Bell Creek mud (pCi/g)	6	.42	30
Bell Creek vegetation (pCi/g ash)	6	.41	184
Bell Creek water (pCi/liter)	6	.04	4.1

[a] Location not shown on figure 1.

Soil and vegetation monitoring

Soil and vegetation are regularly sampled at 24 locations. Twelve sampling stations are located within the boundaries of Atomics International's sites and are referred to as "onsite" stations. The remaining 12 stations, located within a 10-mile radius of the sites, are referred to as "offsite" stations.

Surface soil types available for sampling range from decomposed granite to clay and loam. Samples are taken from the top half-inch layer of ground surface. The soil samples are packaged and sealed in plastic containers and returned to the laboratory for analysis. Radioactivity in soil samples is presented in table 5.

Table 5. Radioactivity in the soil, Atomics, January–June 1969

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g)
Onsite	Alpha	72	0.43
	Beta-gamma	72	27
Offsite	Alpha	24	.46
	Beta-gamma	24	26

Vegetation samples obtained in the field are of the same plant type wherever possible, generally sunflower or wild tobacco plant leaves. These types maintain a more active growth rate during the dry season than do most natural vegetation indigenous to the local area. Vegetation leaves are stripped from plants and transferred to the laboratory for analysis. Plant root systems are not routinely sampled. Radioactivity in vegetation samples is presented in table 6.

Table 6. Radioactivity in vegetation, Atomics, January–June 1969

Area	Type of radioactivity	Number of samples	Average concentration (pCi/g ash)
Onsite	Alpha	72	0.45
	Beta-gamma	72	160
Offsite	Alpha	24	.38
	Beta-gamma	24	142

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	December 1968
July–December 1968	July 1969

2. Feed Materials Production Center[3] January–June 1969

National Lead Company
Fernald, Ohio

The Feed Materials Production Center (FMPC) is operated by the National Lead Company of Ohio for the AEC. The location as related to populated areas is shown in figure 3. Cincinnati and Hamilton, the larger nearby communities, are situated 20 and 10 miles from the center, respectively. Operations at this project deal with the processing of high-grade uranium ores and ore concentrates to produce metallic uranium and with fabricating the metal into fuel elements.

During the past 2 years, the project has also processed thorium to produce purified oxide and metal. The process and use of these products is essentially the same as used in producing uranium. Because of the small amounts of thorium processed by the project, environmental analyses for thorium are not considered necessary.

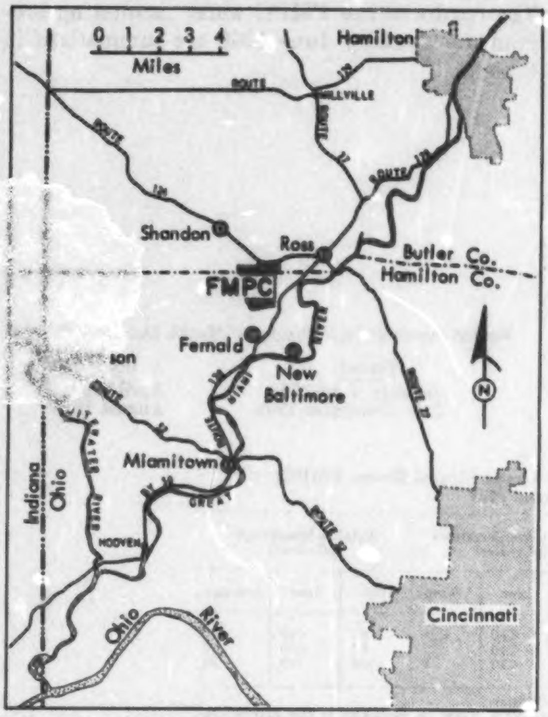
0 1 2 3 4
Miles
Hamilton
ROUTE
MILLVILLE
ROUTE
ROUTE
126
ROUTE 17
ROUTE 129
Shandon
Ross
Butler Co.
Hamilton Co.
FMPC
Fernald
New Baltimore
son
MIAMI
126
ROUTE 27
ROUTE 52
WHITEWATER RIVER
Miamitown
GREAT
Indiana
Ohio
HOOVEN
ROUTE 27
N
Ohio River
Cincinnati

Figure 3. Area map of Feed Materials Production Center

During the many involved reactions and processes that lead to the production of reactor fuels, various liquid and airborne wastes are generated. These wastes contain varying quantities of uranium and thorium. Various in-plant methods are used to curtail their release into the environment surrounding the plant. Almost complete removal of the materials is accomplished by using dust collectors and waste treatment processes. In order to determine what concentrations reach the area surrounding the project, an environmental survey program has been established which consists of water and air sampling of the environs and performing those analyses on the samples that are indicative of material released from the plants.

Air monitoring

Onsite air samples are obtained from four permanent perimeter air sampling stations, located at the four corners of the production area as shown in figure 4. Samples from these perimeter stations are collected once each week and analyzed for uranium and total radioactivity. Offsite samples are collected by a mobile air sampling unit. The location at which samples are collected is determined by local meteorological conditions on the day of sampling. Approximately 20 percent of all samples are taken upwind of the FMPC plant.

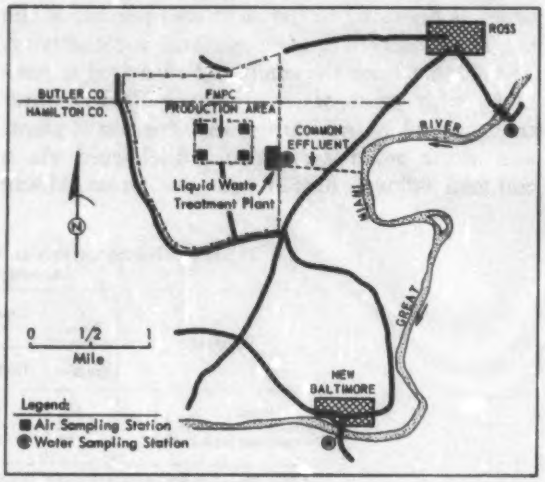
ROSS
BUTLER CO.
HAMILTON CO.
FMPC PRODUCTION AREA
COMMON EFFLUENT
Liquid Waste Treatment Plant
RIVER
MIAMI
GREAT
N
0 1/2 1
Mile
NEW BALTIMORE
Legend:
■ Air Sampling Station
● Water Sampling Station

Figure 4. Air and water sampling stations, FMPC

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[3] Summarized from "Feed Materials Production Center Environmental Monitoring Semiannual Report for the First Half of 1969, Summary Report for 1968" (NLC)-1046.

Table 7. Radioactivity levels of airborne particulates, FMPC, January–June 1969

Location	Number of samples	Uranium concentration[a] (pCi/m³)			Total radioactivity[b] (pCi/m³)		
		Maximum	Minimum	Average	Maximum	Minimum	Average
Onsite:							
Southwest	25	1.0	<0.1	0.3	1.8	<0.1	0.5
Northwest	25	.2	< .1	.1	.5	< .1	.2
Northeast	25	.3	< .1	.1	.8	< .1	.3
Southeast	25	.3	< .1	.1	.6	< .1	.3
All onsite samples	100			.2			.3
Offsite:							
0–2 miles from FMPC	34	2.3	< .1	.4	8.0	< .1	1.1
2–4 miles from FMPC	36	.2	< .1	.1	.7	< .1	.2
4–8 miles from FMPC	30	.3	< .1	.1	.7	< .1	.3
8–12 miles from FMPC	14	.1	< .1	.1	.4	< .1	.2
All offsite samples	114			.2			.5

[a] AEC radiation protection standard—2 pCi/m³

[b] AEC radiation protection standard—100 pCi/m³. Total radioactivity is the sum of the alpha and beta radioactivity.

Replicate samples are taken at each sampling point and averaged to obtain a representative concentration for that location. Concentrations of uranium and total radioactivity of airborne particulates sampled at onsite and offsite locations are given in table 7.

Water monitoring

Each of the individual production plants on the project has collection sumps and treatment equipment to remove the uranium from the process waste water. The effluent from the plants is collected at a general sump for equalization and settling. The clear water from the sump is pumped to the river. The solid portion is pumped to a chemical waste pit for further settling. The flow, which is decanted to the clear well portion of the pit, is virtually free of solids and radioactivity. The effluent from the sump and clear well is combined with waste water from the FMPC water treatment plant, sanitary sewage treatment plant, and storm sewer system and discharged via a common effluent outfall into the Great Miami River. A Parshal-Flume-type water sampler collects samples of the combined effluent stream, which are removed and analyzed daily. These results are utilized with measurements of river flow in calculating the radioactive contaminant concentrations added to the river. Weekly spot samples are obtained upstream; downstream, a continuous sample is taken for a 24-hour period and random samples are analyzed each week. The results of the FMPC water monitoring program for January–June 1969 are summarized in table 8.

Recent coverage in *Radiological Health Data and Reports:*

Period	Issue
January–June 1968	April 1969
July–December 1968	August 1969

Table 8. Radioactivity in the Great Miami River, FMPC, January–June 1969

Location	Number of samples	Uranium concentration[a] (pCi/liter)			Total radioactivity[b] (pCi/liter)		
		High	Low	Average	High	Low	Average
Sewer outfall	181	<10	<10	<10	80	<10	10
Upstream from outfall	23	30	<10	7	60	<10	20
Downstream from outfall	25	20	<10	3	120	10	20

[a] AEC radiation protection standard—20,000 pCi/liter.

[b] AEC radiation protection standard—3,000 pCi/liter. Total radioactivity is the sum of the alpha and beta radioactivity.

Reported Nuclear Detonations, February 1970

(Includes seismic signals foreign test areas)

The U.S. Atomic Energy Commission announced that five nuclear tests were conducted by the Atomic Energy Commission at its Nevada Test Site during February 1970.

Two nuclear tests of the low-intermediate range (20–200 kilotons TNT equivalent) were conducted underground on February 4 and 5, 1970, by the Atomic Energy Commission at its Nevada Test Site.

A nuclear test of low yield (less than 20 kilotons TNT equivalent) was announced by the AEC as having been conducted underground on February 11, 1970, at its Nevada Test Site.

Two other underground nuclear tests of low-intermediate yield range (20–200 kilotons TNT equivalent) were conducted February 25 and 26, 1970, by the Atomic Energy Commission at its Nevada Test Site.

SYNOPSES

Synopses of reports, incorporating a list of key words, are furnished below in reference card format for the convenience of readers who may wish to clip them for their files.

RESULTS OF A PROGRAM DIRECTED TOWARD REDUCTION OF DENTAL X-RAY EXPOSURE. *Robert B. Rosenthal and James C. Malcolm. Radiological Health Data and Reports, Vol. 11, March 1970*, pp. 109–155.

X-ray safety surveys in 208 dental offices revealed that almost one million radiographic films were exposed annually. A special study was made of procedural factors affecting roentgen exposure at the cone tip of dental x-ray machines; these were film speed, developing technique, and kilovoltage. Although only 27 percent of the offices were using slow or intermediate speed film, they were found to be responsible for 45 percent of the total cone-tip exposure. A change to faster film reduced their exposure levels by 54 percent. Offices accepting recommended changes in developing technique reduced their exposure levels by 43 percent. The program's effect was an overall exposure reduction of 27 percent. With properly developed fast film, the median exposure levels ranged from 0.19 R/film at 90–100 kVp to 0.62 R/film at 45–55 kVp. The accuracy of electric and electronic timers was evaluated in selected offices.
KEYWORDS: California, dental, film, surveys, timers, x-ray, x-ray machines.

SURVEY RESULTS OF THE USE OF X RAYS IN THE HEALING ARTS SPECIALTIES IN NORTH DAKOTA, 1964–1968. *James A. Kraeger and Gene A. Christianson. Radiological Health Data and Reports, Vol. 11, March 1970*, pp. 117–128.

The x-ray facilities of all healing arts specialties (except dentistry) in North Dakota were surveyed by the State Department of Health to determine the degree of compliance of the x-ray facilities with the recommendations published in NBS Handbook 76. An average of 8,529 patients is radiographed per week in the helaing arts specialties in North Dakota, for a total of 443,508 patients radiographed per year. Hospitals and multiple-specialty clinics account for 81 percent of the radiographs. An average of 881 patients receives a fluoroscopic examination each week for a total of 45,812 examinations per year. Of this fluoroscopic workload, 88 percent are conducted in hospitals and multiple-specialty clinics. Fifty-eight percent of the diagnostic x-ray machines were found to be deficient upon initial evaluation. The majority of the deficiencies were inadequate collimation and/or inadequate filtration of the useful x-ray beam. Major deficiencies resulting in an unnecessary genetically significant dose were found to exist in facilities that exposure 195,676 persons annually. Forty-nine percent of the individuals operating x-ray equipment in North Dakota are not registered with The American Registry of Radiologic Technologists. Of the non-registered technicians, 76 percent had less than a year of x-ray training and 74 percent indicated that aspects of x-ray protection were not included in their training.
KEYWORDS: Healing arts specialties, North Dakota, survey, X-ray facilities.

STRONTIUM AND PLUTONIUM ISOTOPES IN GROUND LEVEL AIR, OCTOBER 1963–MARCH 1969. *B. Shleien, J. A. Cochran, and P. J. Magno. Radiological Health Data and Reports, Vol. 11, March 1970*, pp. 129–134.

Data are presented on monthly concentrations of strontium–90, strontium–89, plutonium–239, and plutonium–238 in ground level airborne particulates collected at Winchester, Mass., from October 1963 (for radionuclides of strontium) and May 1965 (for radionuclides of plutonium) to March 1969. The ratio of strontium–89 to strontium–90 in these samples indicates an influx of strontium–90 following all but the sixth atmospheric detonation on the Chinese mainland. It is estimated that in 1968 approximately 60 percent of the strontium–90 present in ground level air was of post-1963 origin. The ratio of plutonium–239 to strontium–90 prior to February 1968 was 0.017 ± 0.009. There was a gradual increase in this ratio later in 1968 which is attributed to debris following the sixth, seventh, and eighth tests on the Chinese mainland. Levels of plutonium–238 in SNAP-9A debris in ground level air are somewhat lower than had been predicted.
KEYWORDS: Airborne particulates, Massachusetts, plutonium–238, plutonium–239, strontium–89, strontium–90.

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